INTRODUCTION TO CLIMATOLOGY

- Climatology is simply the scientific study of the climates.
- Building Climatology is therefore the scientific study of climates with regards to the built environment. Buildings do not exist in isolation; they exist within a particular geographical context. Architecture as a scientific discipline seeks to ensure that the building and the contextual geographical environment are in a symphonic unity. If this is not achieved, the building will not yield maximum user comfort and will thus not fulfill its purpose.

  Weather: Weather is a sum total of atmospheric conditions of a relatively small geographical area in a short period of time.
  Climate: Climate on the other hand, is the sum total of atmospheric conditions observed in large geographical area over a long period of time. The period of this observation could be 25 – 30 years. Hence, climate can be said to be an average of weather conditions taken over a long time.

CLIMATIC ELEMENTS AFFECTING THE BUILT ENVIRONMENT

There are five major climatic elements affecting the built environment.

- temperature,
- humidity,
- wind,
- atmospheric pressure
- and precipitation.

1. **Temperature** -is the degree of hotness or coldness of the atmosphere. Of all the other climatic elements, temperature is the most important because it influences the other elements. Temperature goes a long way to influence thermal comfort of the building.
   Thermal comfort is the condition of the mind which expresses satisfaction with the thermal environment. The human thermal environment is not straight forward and cannot be expressed in degrees. Nor can it be satisfactorily defined by acceptable temperature ranges. It is a personal experience dependent on a great number of criteria and can be different from one person to another within the same space. For example, a person walking up stairs in a cold environment whilst wearing a coat might feel too hot, whilst someone sat still in a shirt in the same environment might feel too cold.

Other effects of temperature on buildings

a) Thermal expansivity. Building components such as metals expand when hot and contract when cold. The higher the temperature rise in a building, the more the expansion of building components in that building. We may not readily see the effects of this due to

the small of fraction of change that occurs, but over the years, the wear and tear will be evident.

b) Economic effect. The cost of mechanical Heating, Ventilation and Air Conditioning (HVAC) will normally rise with adverse effect of temperature rise or decline. During the hot season, mechanical ventilators and air conditioners are over worked which leads to the probable damage of these systems. The operational cost too and cost of repairs and servicing will be on the increase. Conversely, during the cold season, there may be attendant need to look alternative means of heating up indoor spaces; this too is will lead to further expenses.

2 **Humidity-** is the amount of water vapour in the atmosphere. It becomes Relative Humidity when a ratio is taken between the actual amount of water vapour in the air and the maximum amount of water vapour that the air can hold at that given air temperature. Like earlier said, it is usually given as a percentage. The effects of humidity can be seen as it effects thermal comfort. In a very humid environment, people will tend to sweat a lot, and clothes will not get dry easily after laundry.

3 Effects of wind on building

Wind is air in motion. It is caused by horizontal variations in air pressure. The greater the difference in air pressure between any two places at the same altitude, the stronger the wind will be. Wind speed is the rate at which the air moves past a stationary object. Wind is the major component of ventilation in buildings. The pressure between the building envelope and the external environment differ, and that is why ventilation is possible. Adequate fenestration is required to harness this. Spread of communicable diseases is faster in poorly ventilated places. In as much as wind is needed for ventilation, the adverse effect of wind on buildings can be quite detrimental. Prime of these adverse effect is that of wind-load on high-rise buildings. In the design and construction of high-rise buildings, the impact of wind-load must be taken into cognizance.

4. Pressure

Air is held to the earth by gravity. This strong invisible force pulls the air downward, giving air molecules weight. The weight of the air molecules exerts a force upon the earth and everything on it. Consequently, air pressure always decreases with increasing height above the ground. Because air can be compressed, the density of the air normally is greatest at the ground and decreases at higher altitudes.

Whereas atmospheric pressure may not have direct effect on low-rise buildings, in the construction of very tall buildings such as sky scrapers, pressure becomes a serious part of design considerations.

5. Effects of Precipitation and Vapour Pressure on buildings

Precipitation is the product of a rapid condensation process (if this process is slow, it only causes cloudy skies). It may include snow, hail, sleet, drizzle and rain.

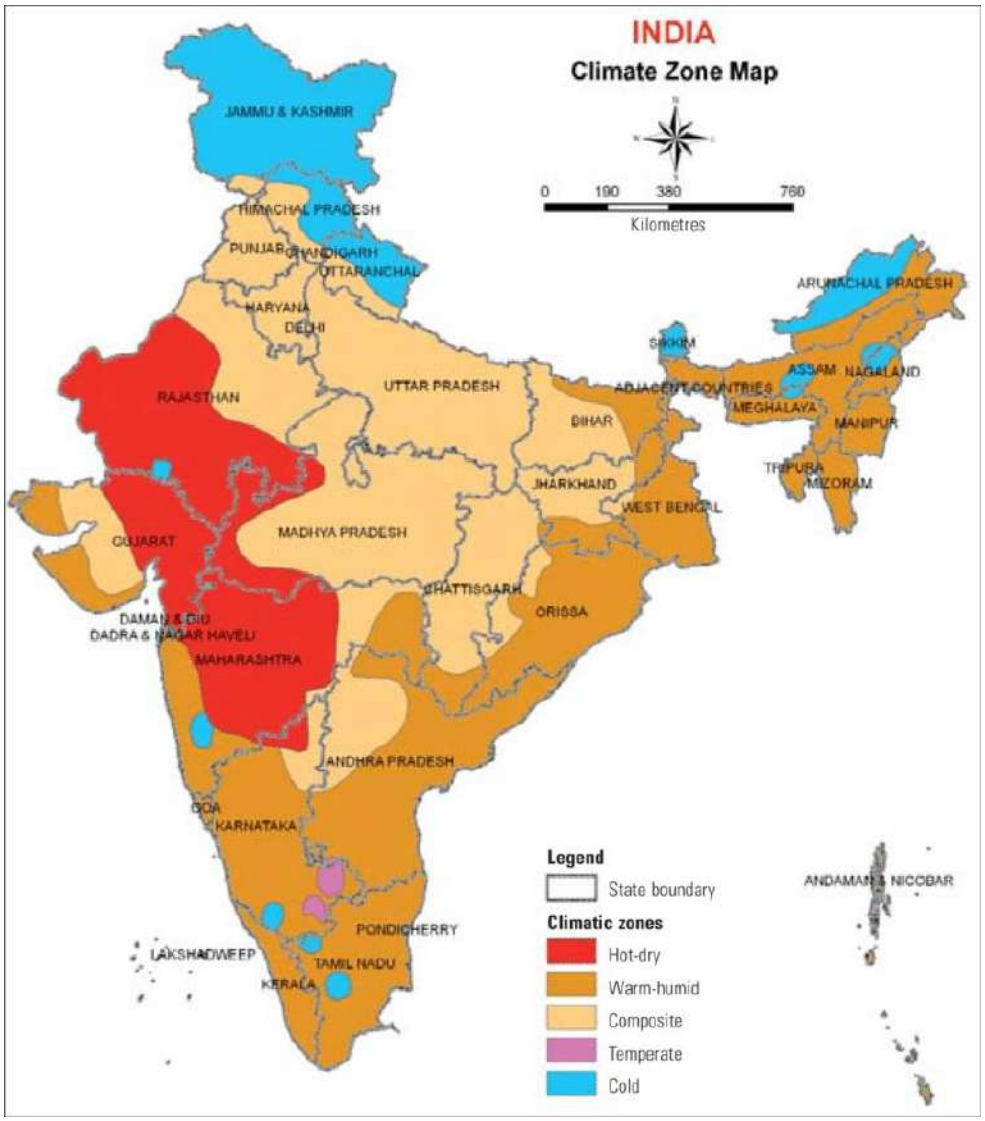
Water damage can ruin building contents, and cause costly closures for repairs. Poorly sloped roofs and defective workmanship are readily observed in the event of heavy downpours. Paints and other surface finishes could peel off as result of moisture rise, flooring and floor finishes are not left out too especially for places that are prone to capillary action of underground water.

Climatic Zones of India

Introduction

♦ Regions having similar characteristic features of climate are grouped under one climatic zone.

According to a recent code of Bureau of Indian Standards, the country may be divided into five major climatic zones:



1) **Hot & Dry** (mean monthly temperature >30 and relative humidity <55%);
2) **Warm & Humid** (mean monthly temperature >25-30 and relative humidity >55-75%);
3) **Temperate (**mean monthly temperature 25-30 and relative humidity <75%);
4) **Cold** (mean monthly temperature<25 and relative humidity-all values)
5) **Composite** (This applies, when six months or more do not fall within any of the other categories)

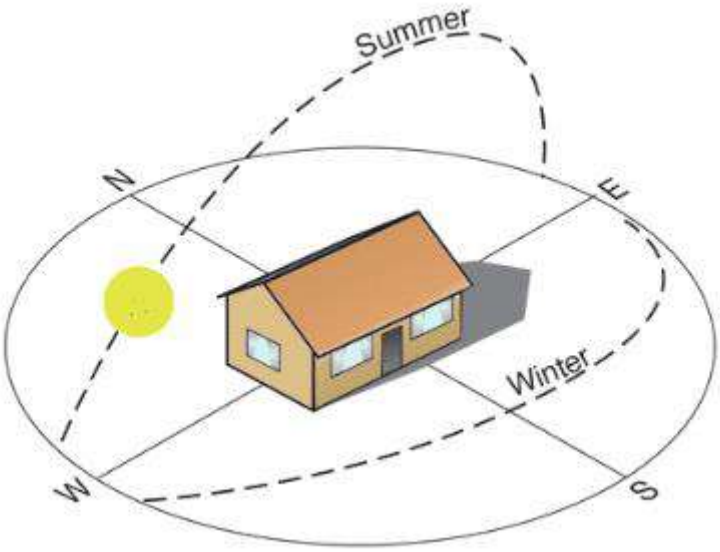
Orientation of building should be done for the climatic zone in which the building is situated. The purpose of orientation is to provide residents a comfortable living space throughout the year even under severe undesirable weather conditions.

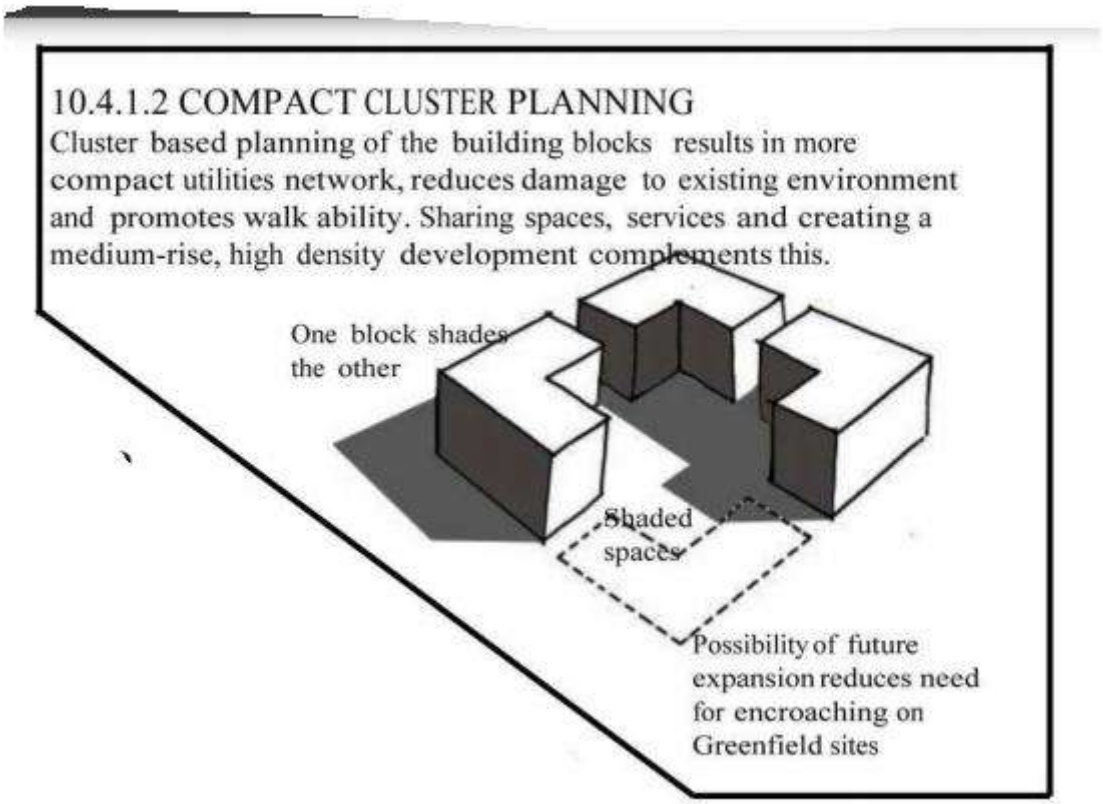
Buildings in different climatic zones require different passive features to make structures energy-efficient. Some features that can be adopted in particular zones are listed below.

1. Hot and dry climatic zones: . Maximum daytime summer temperature goes as high as 45 degree centigrade and relative humidity as low up to 20 %.
This type of climate is experienced in areas far from sea coasts and do not receive heavy rainfall. Thus, the humidity is very low. So, the buildings in this climatic zone should be orientated based on solar point of view so that the building receives maximum solar radiation during winter season and minimum radiation during summer season.

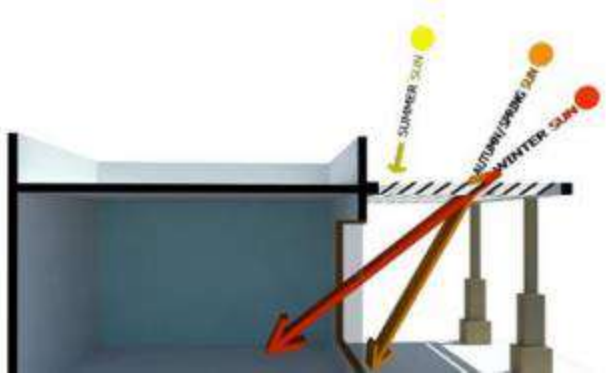
Climatic of the hot and dry region are:
1. Hot dry in summer and cold in winter
2. Very little rainfall
3. Very low humidity
4. High temperature difference between night and day
5. Hot winds and frequent dust storms
6. High summer day time temperature (32-36 c)
7. High direct solar radiation
8. Clear sky most of the year
9. Sandy or rocky ground with very low vegetation cover

Desirable features of buildings in hot and dry climatic zones are:
1. Orientation of building: Orientation of building in this climatic zone should be such that non-habitat rooms can be located on outer faces to act as thermal barrier. Longer walls of building should face North & South so that the building gets minimum solar exposure. Preferably the kitchen should be located on leeward side of the building to avoid circulation of hot air and smell from the kitchen.





2. Windows and Openings in Walls: Windows and large openings in walls with heavy shutters should be provided on northern and western faces as light coming from north is always diffused and indirect. Also direction of breeze, which is from west at most of the places, enters from opening on west side. Windows area should be 15 to 20 percent of floor area.



Internal courtyard caters for cross ventilation & thermal buffer. Suitable radiation barriers in the form of canopies, Chajjas, long verandahs etc. should be provided on the West side of the building. Sufficient number of ventilators close to the bottom of slab should be provided for hot air to escape the room.

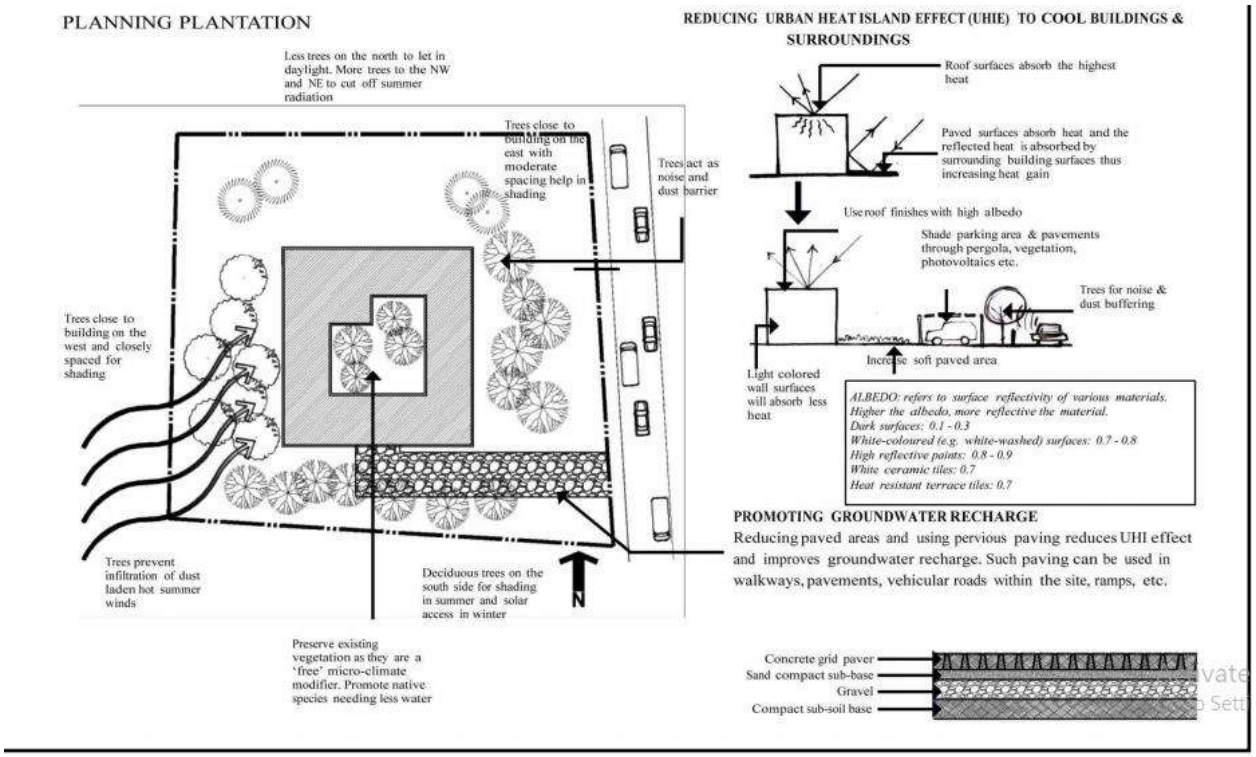
3. Walls: Thickness of wall plays an important role in heat insulation of building. Thicker outer walls are preferred as it behaves as an insulating barrier. Painting of walls from outside also plays an important role. Walls with light and shining paints on outer surface have good reflective quality and do not absorb heat. The surface of walls should be smooth and non-dust catching type.

Walls constructed with hollow blocks / bricks and **Cavity Walls** can also be provided as they provide very good thermal insulation.

4. Insulation of Roofs: Roofs should be built up with good insulating material having slope in windward direction and which reflects the radiation and does not absorb heat. False ceiling can be used to improve thermal performance of building.

Terracing should be provided on the flat roof with mud phuska, lime concrete, foamed concrete or burnt clay block paving over roof slab. Top roof surface should be made reflective by providing whitewashing or any reflective paint.

5. Growing of Vegetation: Large shady trees whose roots do not strain foundation and basement should be planted near external walls to provide shade.



6. Special Building Orientation Requirements: Outdoor sleeping area for summer nights preferably is provided. Desert coolers and fans can be used during summer months. Therefore, proper space to provide coolers should be planned in the building.

7.Landscaping

Landscaping is an important element in altering the microclimate of a place. Proper landscaping reduced direct sun from striking and heating up building surfaces. It is the best way to provide a buffer for heat, sun, noise, traffic, and airflow or for diverting airflow or exchanging heat in a solar-passive design.

Fig. 7. Landscaping

The use of dense trees and shrub plantings on the west and southwest sides of a building will block the summer setting sun.

Fig. 8. Natural cooling

CONCLUSION

BUILDING DESIGN:

1. Detailing building fenestration design and **construction** details to promote shading, heat loss and insulation.
2. Larger building dimensions should face north & south.
3. Double walls with insulation in between are a suitable solution
4. The size of the windows on the east and west sides should be minimized in order to reduce heat gain
5. The flat roof is a good reflector and re-radiates heat efficiently, especially if it consists of a solid, white painted material.
6. The courtyard is provided with water and plants, it acts as a cooling source.
7. Internal courtyards provide cross ventilation and natural cooling.
8. Inlets to be provided at lower levels and outlets at a higher level as they serve to vent the hot air.
9. Suitable radiation barriers in the form of canopies, chajjas, and long verandahs should be provided on the west side of the **building**.

- Madhya Pradesh – **The places which have a hot and dry climate in MP is Gwalior, Jabalpur, Sagar, Rewa, Singrauli.**

- Gujarat – **Ahmadabad is the capital which has the maximum hot and dry climate throughout summer.**

- Andhra Pradesh – **Vijayawada, Khammam, Thallarevu (East Godavari) are some of the southern places in AP.**

Effect of Climate on man and shelter

The pattern of human life in any particular region is to a very large extent determined by the climate.

Shelter:

The design of houses in different geographical regions of the world is determined by climatic conditions. In areas of heavy rainfall, the houses have sloping roofs. The material used in construction is, however, determined by the availability of construction material. The roof could be tiled or comprise bamboos covered with hay where clay for making tiles may not be available.

In dry regions like Rajasthan, flat stone pieces are used for roofing. Partition walls are made of wood in very cold countries. In regions of high temperature, there are open courtyards attached to each dwelling. In hill districts houses are made on stilts with the ground floor reserved for cattle.

Dress:

Loose dresses are popular in regions where the climate is hot. In colder regions, people wear dresses that are body hugging. A very wide variety of head gears is used again depending on the climate.The lungi is popular in the southern regions of the country where it is relatively hot but not so in colder region as Himachal Pradesh. Woollens are worn in cold regions while cotton clothing is worn in hot and temperate regions. Synthetic clothing may be suitable in cold climates but not so at places where people perspire during the day.

Occupations:
During the winter months when outdoor living is not easy, the people of Kashmir remain indoors and follow up occupations like making carpets, handicrafts; silk wares that can be weaved sitting indoors. Agriculture is practiced where rainfall is adequate.

People living in dry regions follow pastoral occupations moving from place to place along with their herds of cattle looking for water and grass where ever it may be available. Where rainfall is abundant, forestry comes up as an important occupation for the people.

Art and Culture:
Open air stage performances are popular in areas that are not very cold. A wide variety exists at places where people have opportunity to remain out doors for most part of the year.

Food habits:
Since climate determines the nature of crops that can be grown in any part, the food habit also get influence by the climate. In Bengal, the staple food is rice since heavy rainfall in that region is most suited for paddy cultivation. The northern parts of the country, wheat are the

staple diet. Millets are popular in dry regions like Rajasthan. Crops like Bajra are grown there since this crop can survive even with scant water supply. The people living in Tundra region have no chance of being vegetarians. The climate does not allow growing any cereals or food crops.

Migration:

People living in extremely cold climates are known to migrate to warmer places in search of jobs. Where the climates are temperate, people tend to live a more settled life.

A bioclimatic chart helps architects design energy-efficient buildings.

- A bioclimatic chart is a preliminary analysis tool used during the early planning stages of a building project.
- Known as bioclimatic architecture, an architect uses the bioclimatic chart to design buildings that include the most efficient passive cooling and heating strategies based on the climate and location of a building site, according to the Center for Renewable Energy Sources and Saving.

HOW TO CREATE BIO CLIAMTIC CHART

1 Accumulating Chart Data

- In order to create a bioclimatic chart, monthly statistical data is collected.
- The chart is used to plot the average maximum and minimum temperature and the average maximum and minimum relative humidity.

2. Plotting the Chart

- To create a bioclimatic chart two points are plotted for each month.
- The first plot point is used to indicate the minimum temperature and maximum relative humidity, also known as RH.
- The second plot point is used to indicate maximum temperature along with the minimum RH.
- The two points are connected with a line.
- Each line on the bioclimatic chart represents an average day's changes in temperature and humidity.
- To be effective, the chart is developed over a one-year period.

Strategies

- A completed bioclimatic chart will indicate the boundaries for different types of passive design strategies.
- Passive solar heating can be assessed using the chart as well as passive cooling strategies.

- Additionally, the chart can indicate a comfort zone where no cooling or heating is required to maintain thermal comfort.
- An architect will then use the chart to start planning the type of project best suited for a particular climatic location.
- Doing so creates energy-efficient bioclimatic buildings that enhance the quality of life for its users.

Benefits

- The building sector accounts for nearly 40 percent of national final energy consumption, according to the Center for Renewable Energy Sources and Saving.
- This type of energy consumption, using mostly oil as well as electricity, causes the major atmospheric pollution responsible for the greenhouse effect and climatic change. Energy consumption is also a major economic burden.
- Using a bioclimatic chart helps an architect use simple building techniques and methods that reduce energy consumption, such as incorporating a passive solar heating system, natural cooling systems and techniques, as well as natural lighting systems and techniques.

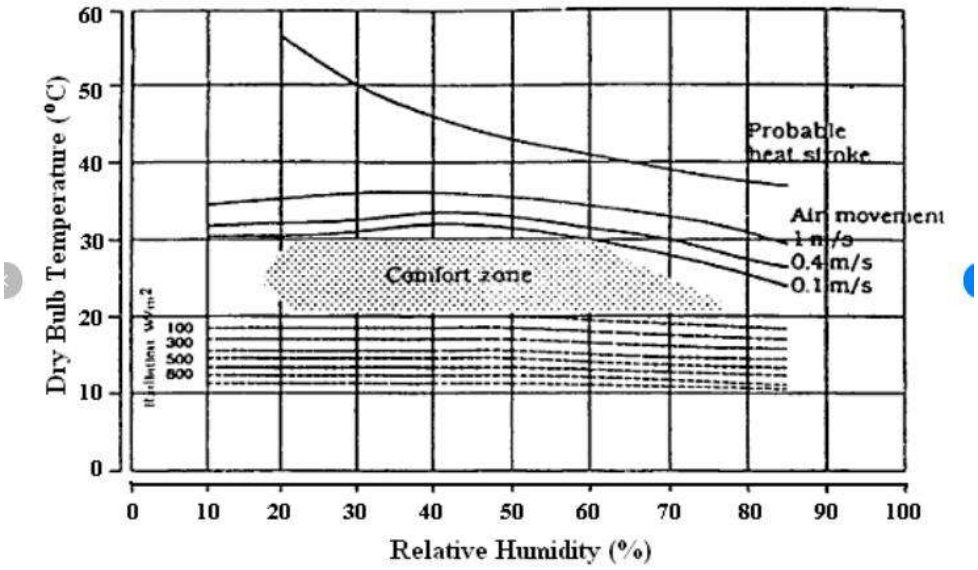
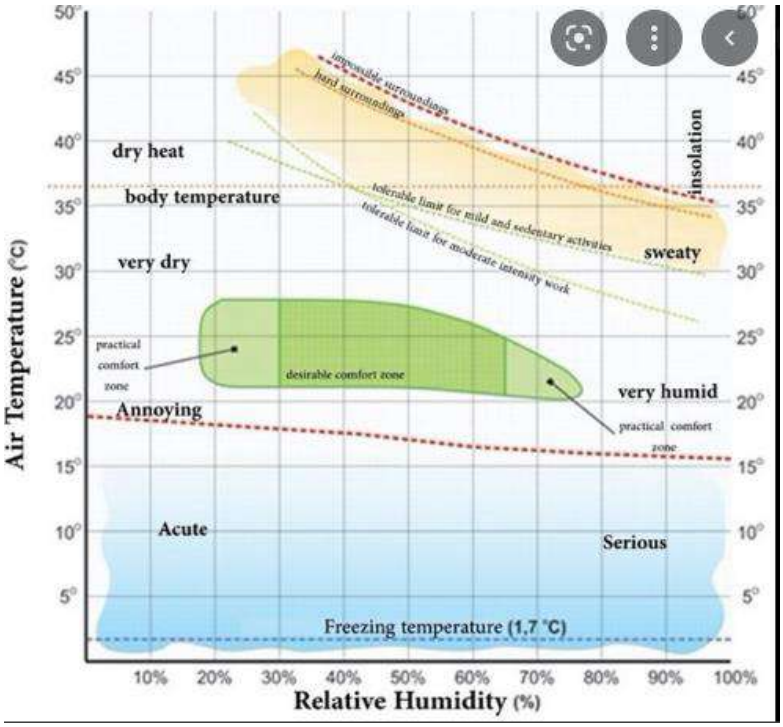
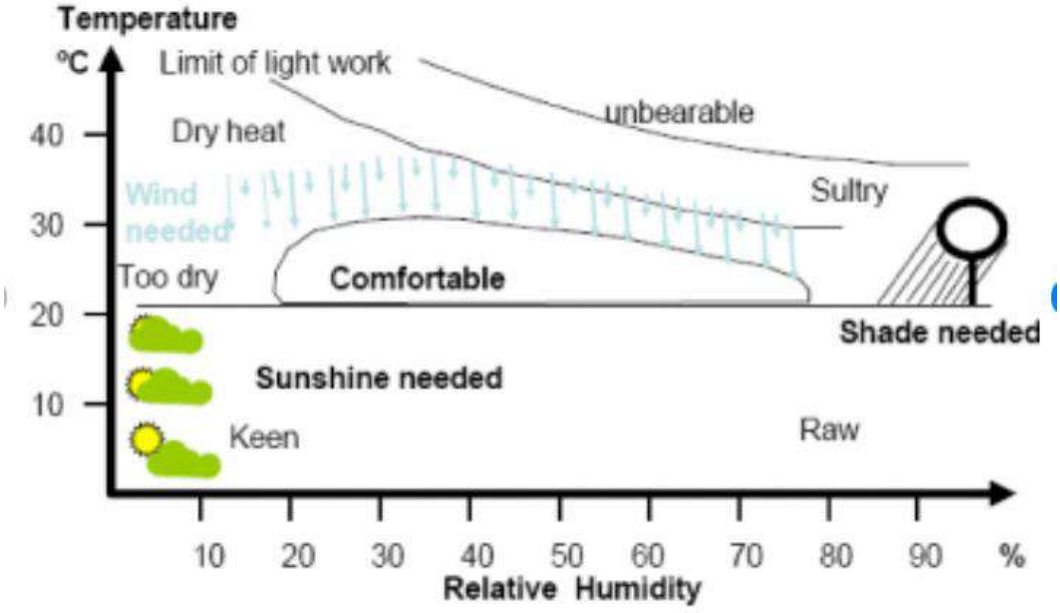


Figure 1





The Olgyay bioclimatic chart (11) (adapted with permission by Martin Wilkinson, University of Bath)

Macro and Micro Climate

Macro-climate the climate of a larger area such as a region or a country
Micro-climate the variations in localized climate around a building.

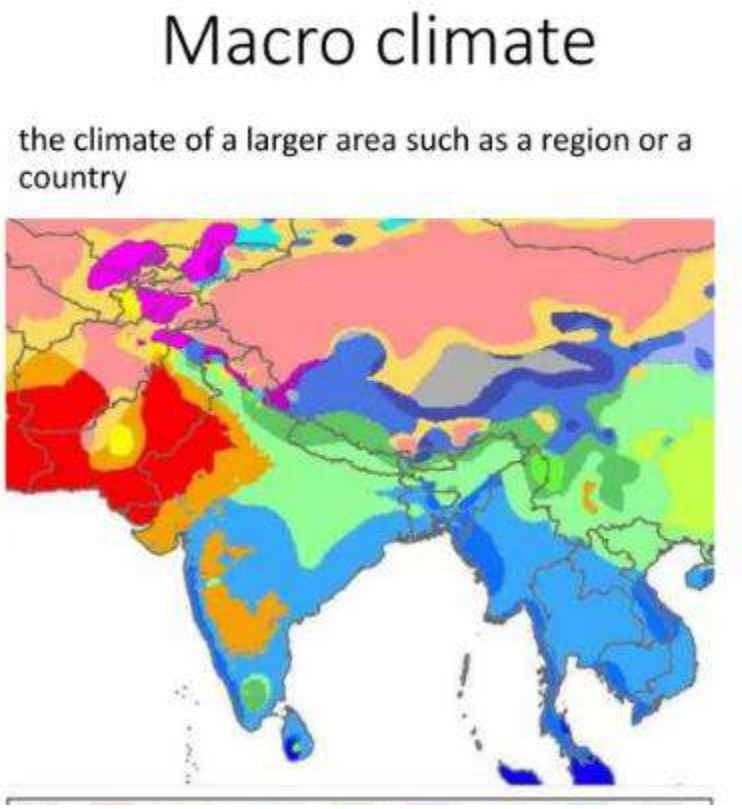
Factors that influence Microclimate

The microclimate is affected by the weather, and the weather is affected by the wind, temperature, relative humidity, precipitation, and atmospheric pressure. There is a clear relationship between wind and temperature: the temperature is cooler in an area with light wind and warmer in an area with heavier wind.

A microclimate is Affected by the following factors:

- Area and local climate
- Site surrounding
- Site shape
- Topography features
- Surrounding Buildings

Macro Climate



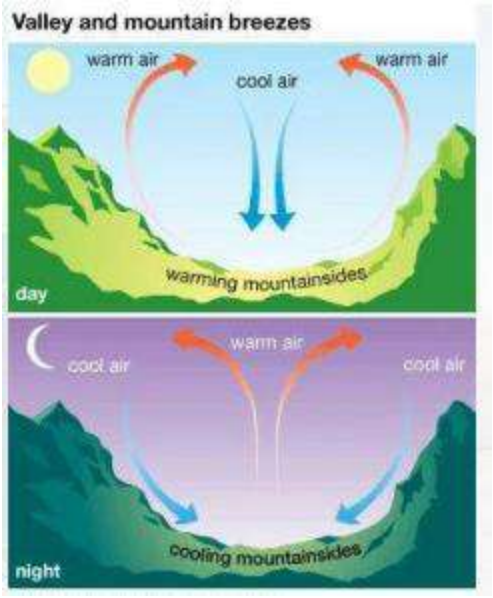
Macroclimate is the climate of larger areas such as a region or country.

The macro and microclimate both have a crucial effect on both the energy and atmospheric performance of buildings during the summer season.

The construction site affects exposure to the prevailing wind, the solar radiation the building receives, pollution level, temperature and rain penetration.

<u>Macroclimate is Affected By the following factors:</u>

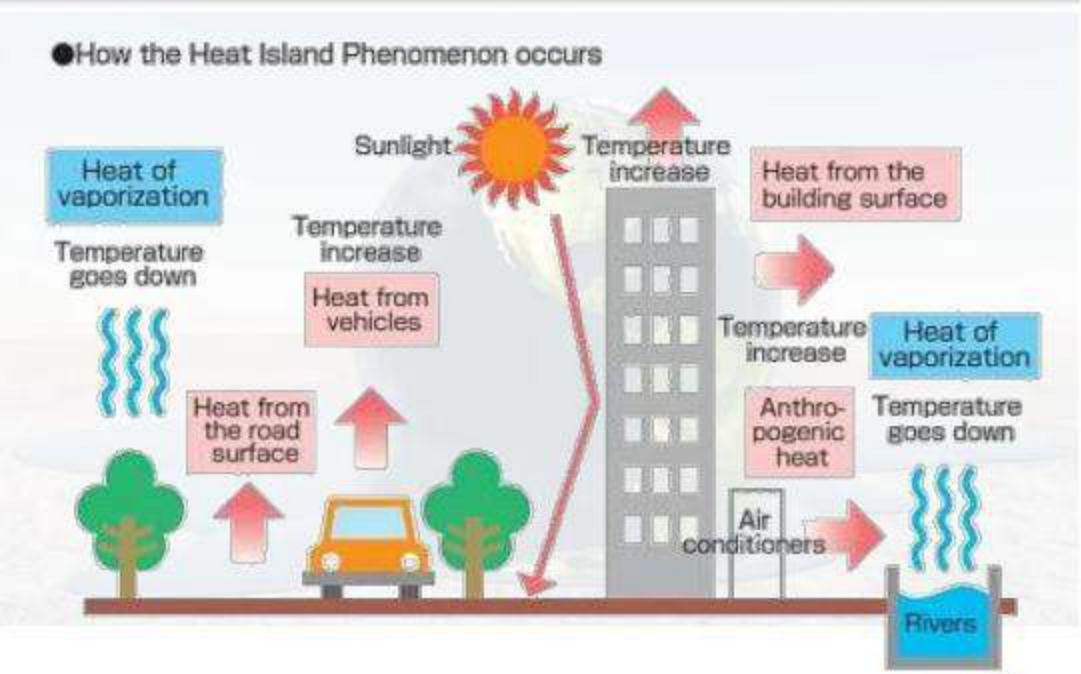
- Topography- The Shape of the land

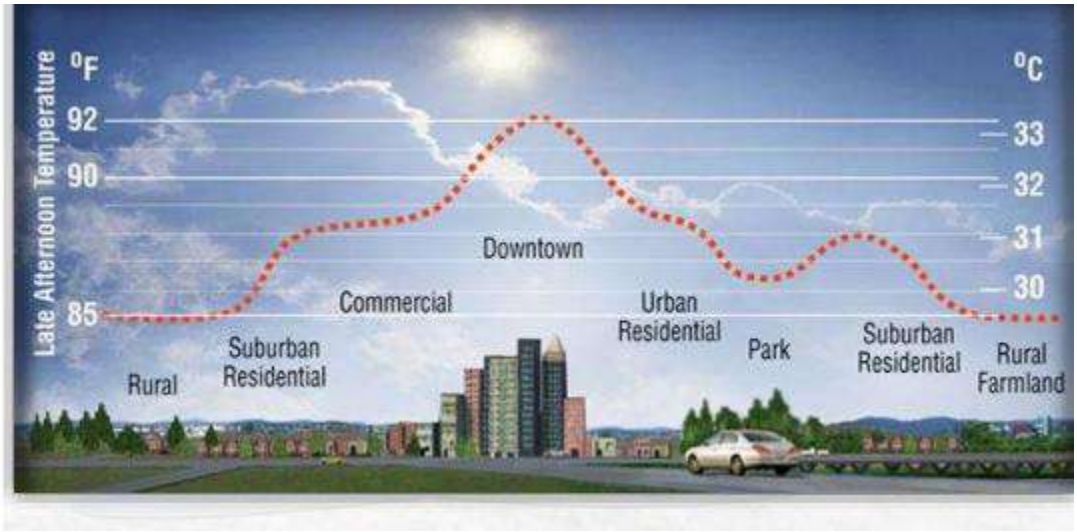
- 

- Sun angle exposure
- Vegetation
- Waterbody
- Physical Infrastructure
- Urban Layout
- Energy Demand
- Open Spaces
- Vehicle Population

Micro-Climate – Effects of Buildings

- Buildings themselves create further micro-climates by shading the ground, changing wind flow patterns.
- One example of how buildings affect the local climate is the heat island effect in large cities where the average temperature is higher than the surrounding area:
- Solar energy absorbed and re-emitted from building surfaces, pavements roads etc. creates a warming effect on the surrounding air. Also the large quantities of buildings break up the wind flow, reducing wind speeds and causing the warm air to remain stagnant in the city. This also causes increased pollution as well as temperatures.

- 

- 

The presence of local high rise buildings can degrade the local climate as wind speed at ground level can be significantly increased, while extensive shadows block access to sunlight for long periods, increasing space heating costs in surrounding buildings.

Improving Micro Climate through Design

The aims of enhancing Micro-Climate around Buildings:

- Reduce costs of winter heating
- Reduce summer overheating and the need for cooling
- Maximize outdoor comfort in summer and winter Also:
- Improve durability of building material (reduced rain penetration)

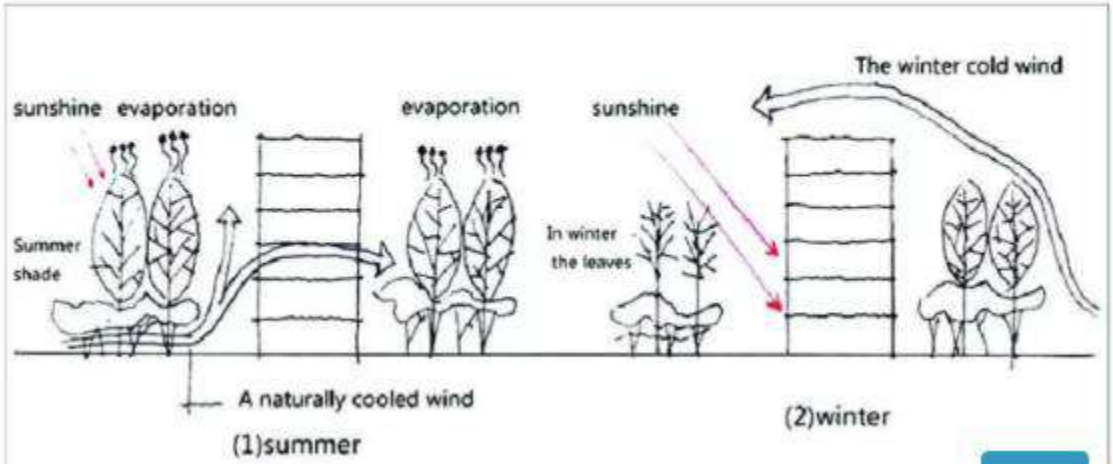
- Provide a better visual environment in spaces around buildings
- Encourage growth of plants
- Discourage growth of mosses and algae
- Facilitate open air drying of clothes
- Means of enhancing the micro climate around a building include

Two main possibilities for influencing Micro Climate are Solar Access and Wind Control

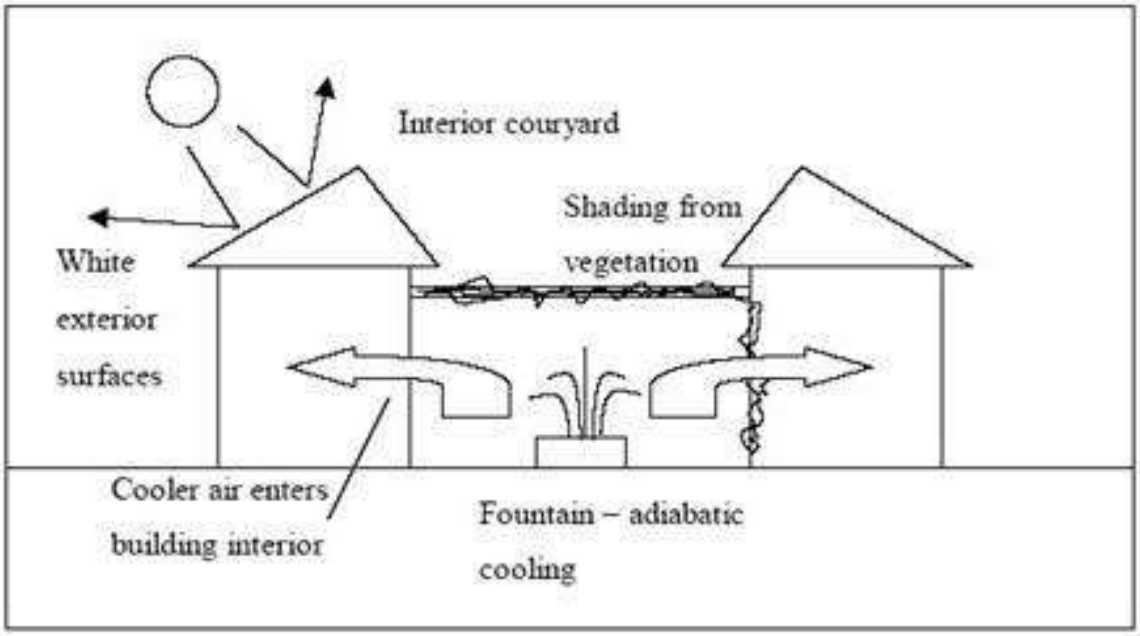
Solar Access

- Solar access to a site is often a case of minimizing solar overheating in summer while maximizing solar access during the winter.
- Buildings with a heating requirement should be orientated north south with maximum glazing on the south face.
- Deciduous trees offer an excellent means of site shading, with shading being reduced in winter when the trees lose their leaves.

The location of neighbouring trees and buildings affects the solar gains (shading) and wind patterns.



- The color of surrounding surfaces will have a pronounced effect on the solar Radiation available to the building.
- Light colored paving will increase the radiation reflected from the ground into the building. Paving stones will also provide external thermal mass, moderating temperature swings immediately adjacent to the building.
- Grass planted outside a building will reduce the ground reflected solar.
- Use of courtyards and water can also moderate the effects of high temperatures on summer.

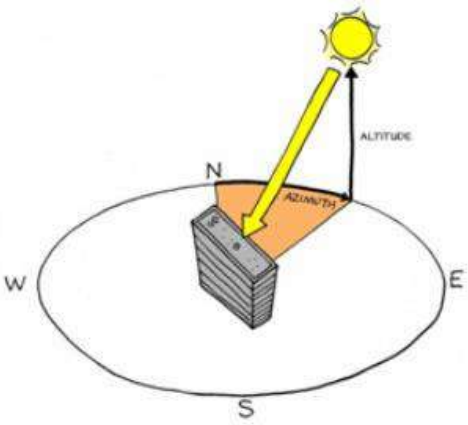


For reference

Wind Control

The form of the building can have a great effect on the impact of the wind:

- Avoidance of the building side facing the wind
- Avoidance of flat roofed buildings and cubical forms
- Avoid piercing buildings at ground level
- Avoid abrupt changes in building heights
- Orientate long axis of the building parallel to the direction of the wind
- Use podium to limit down draught at ground level
- Use pitched rather than flat roofs and stepped forms for higher buildings
- Groups of buildings can be arranged inirregular patterns to avoid wind tunneling.
- Coniferous trees and fencing and other landscape features such as mounds of earth and hedges can also reduce the impact of wind and driving rain on the building structure.


ALTITUDE
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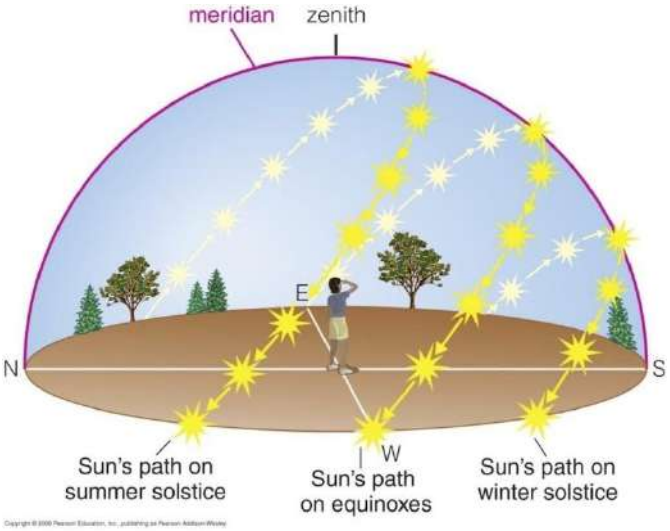
meridian
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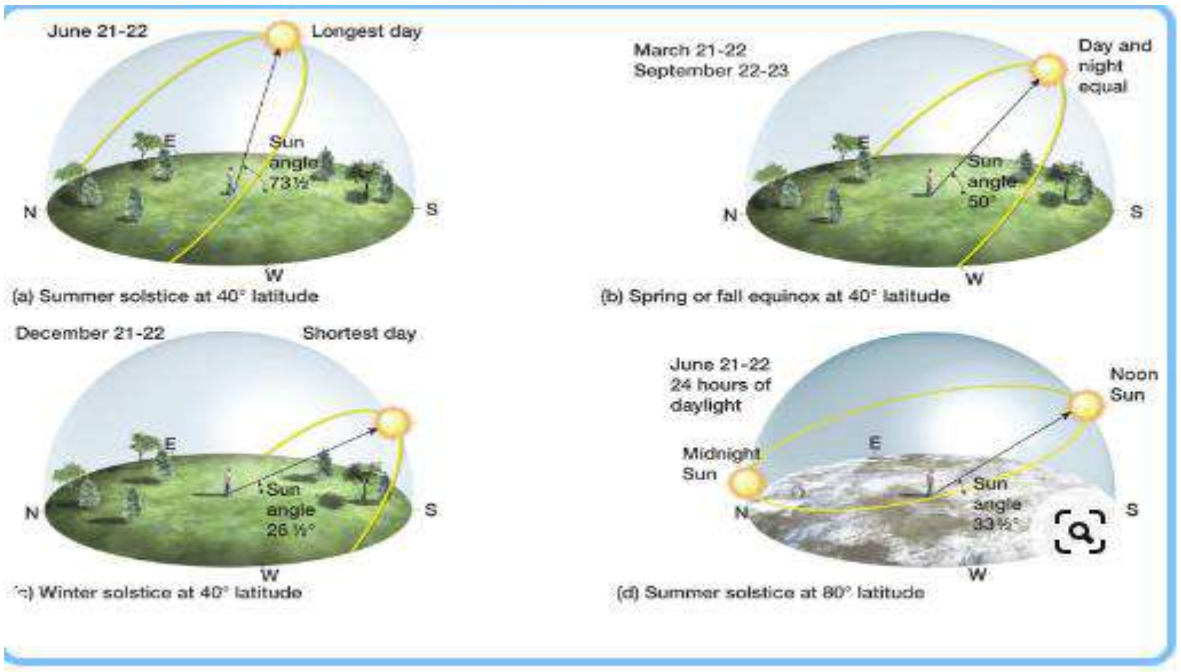
Sun's path on summer solstice
Sun's path on equinoxes
Sun's path on winter solstice

June sep dec


June 21-22
Longest day
Sun angle 73½°
(a) Summer solstice at 40° latitude
March 21-22
September 22-23
Day and night equal
Sun angle 50°
(b) Spring or fall equinox at 40° latitude
December 21-22
Shortest day
Sun angle 26½°
(c) Winter solstice at 40° latitude
June 21-22
24 hours of daylight
Noon Sun
Midnight Sun
Sun angle 33½°
(d) Summer solstice at 80° latitude

- **Sun path** refers to the apparent significant seasonal-and-hourly positional changes of the sun (and length of daylight) as the Earth rotates, and orbits around the sun.
- **Sun-path diagram** as the name suggests is something that is used to determine the location ,in the sky, of the sun at any point of time during the day, throughout the year.

OR

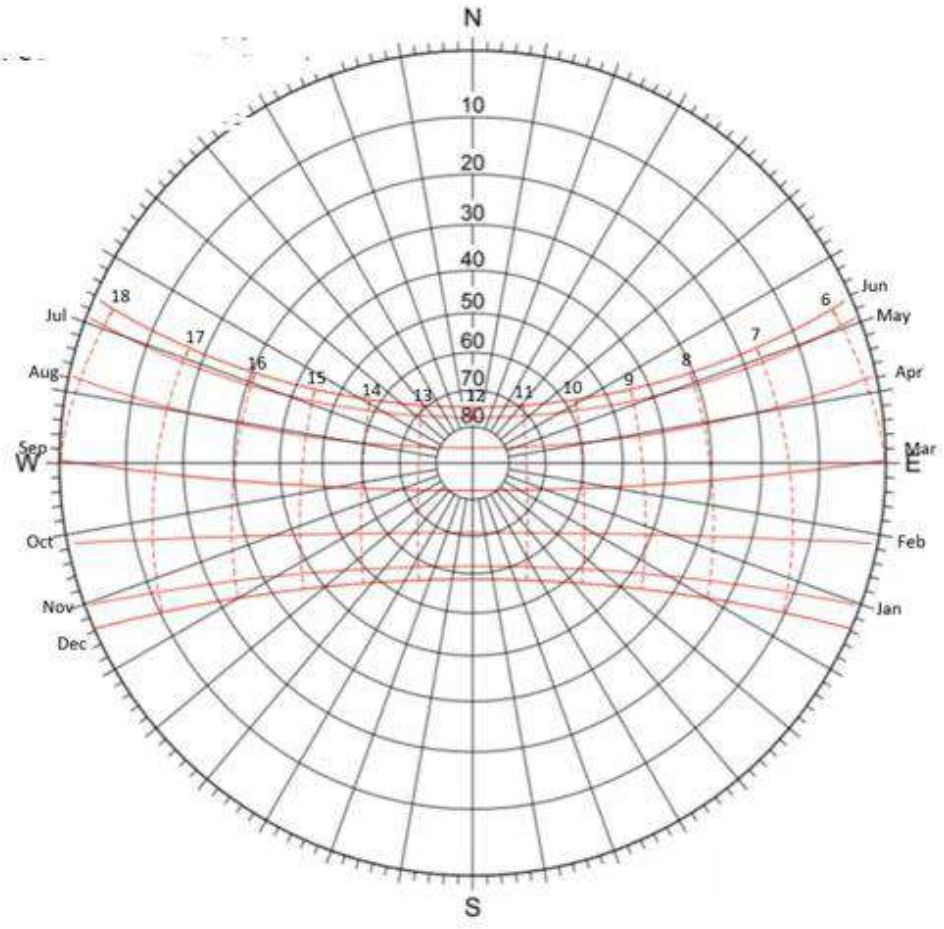
Sun-path model as a simple helping tool for architecture students in understanding saving energy building design

USES

The most immediate use of a sun-path diagram is that the solar azimuth and the altitude can be read and hence the position can be exactly determined..

- By studying the sun-path diagram of a place one can identify the optimal orientation of solar panels in a given building.

- By tracing down the surface area illuminated, to the greatest extent, by the sun, the location of clerestories and fenestrations of a building can be optimised so that the thermal and visual comfort levels in the building are met.
- The shading devices also can be designed similarly.



STEP 1: IDENTIFY THE MONTH-

STEP 2: IDENTIFY THE TIME--

STEP 3: FIND THE ALTITUDE-

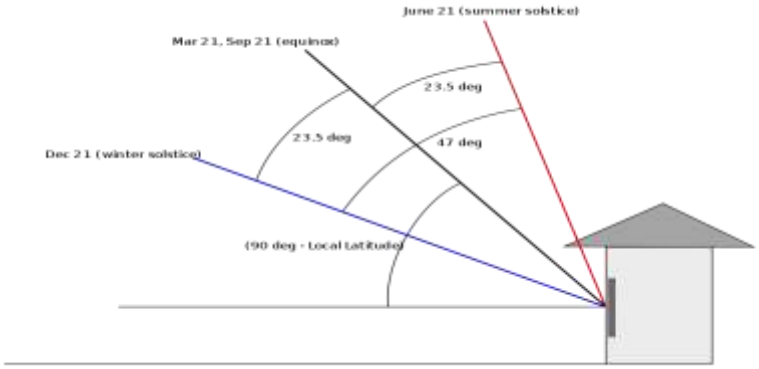
STEP 4: FIUND THE AZIMUTH

UNIT-III
(Solar Chart- Sun Path diagram)

Sun path, sometimes also called day arc, refers to the daily and seasonal arc-like path that the Sun appears to follow across the sky as the Earth rotates and orbits the Sun. The Sun's path affects the length of daytime experienced and amount of daylight received along a certain latitude during a given season.

The relative position of the Sun is a major factor in the heat gain of buildings and in the performance of solar energy systems. Accurate location-specific knowledge of sun path and climatic conditions is essential for economic decisions about solar collector area, orientation, landscaping, summer shading, and the cost-effective use of solar trackers.

Sun path diagrams can tell you a lot about how the sun will impact your site and building throughout the year.



Sun Radiation & Position

- Determination of sun position required before shading devices or indoor solar gain can be established.
- Movement of sun is predictable but varies at different times of year depending on latitude and longitude of a place.

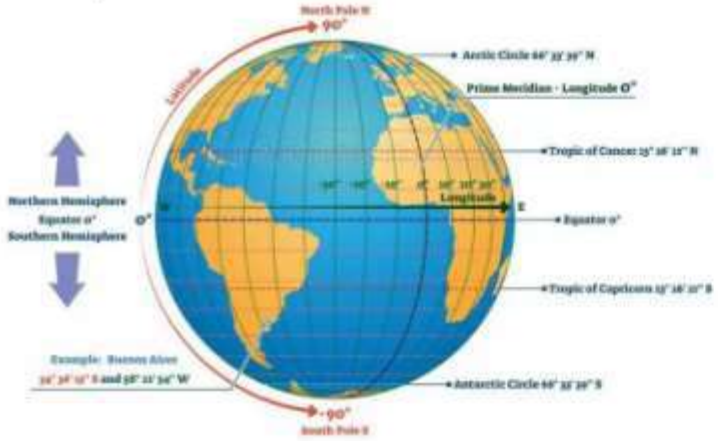


Figure 2.1a Lines of Latitude

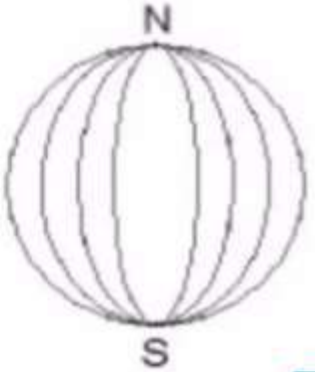
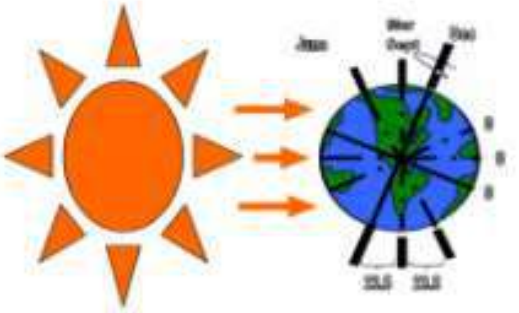


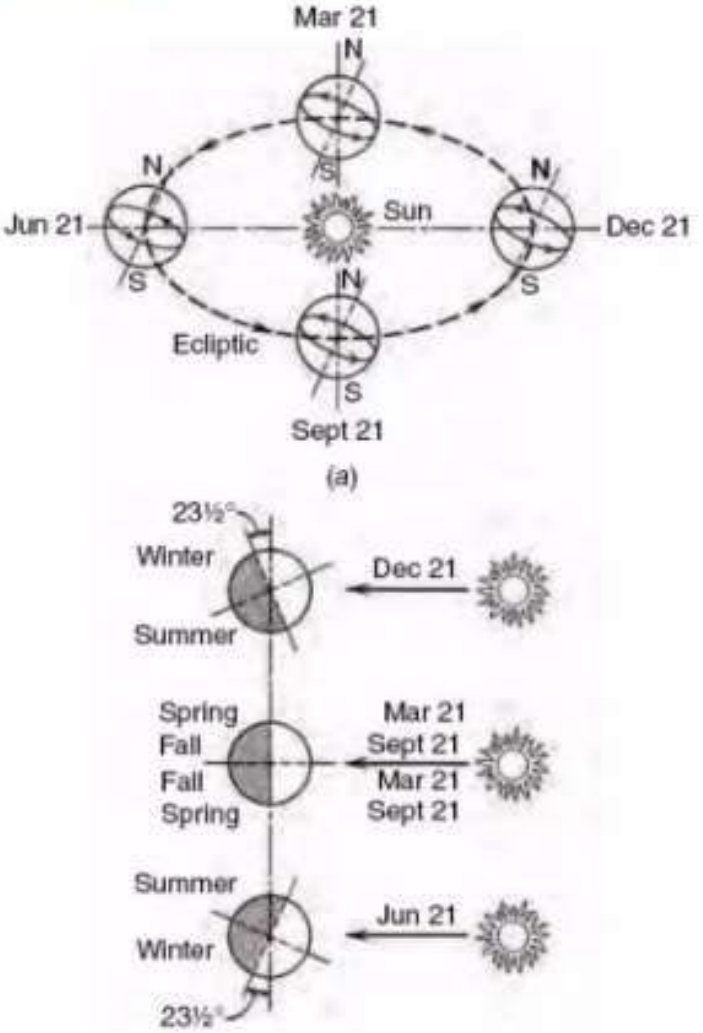
Figure 2.1b Lines of Lo

Understanding of the sun's position

(A) EARTH'S ROTATION AND TILT

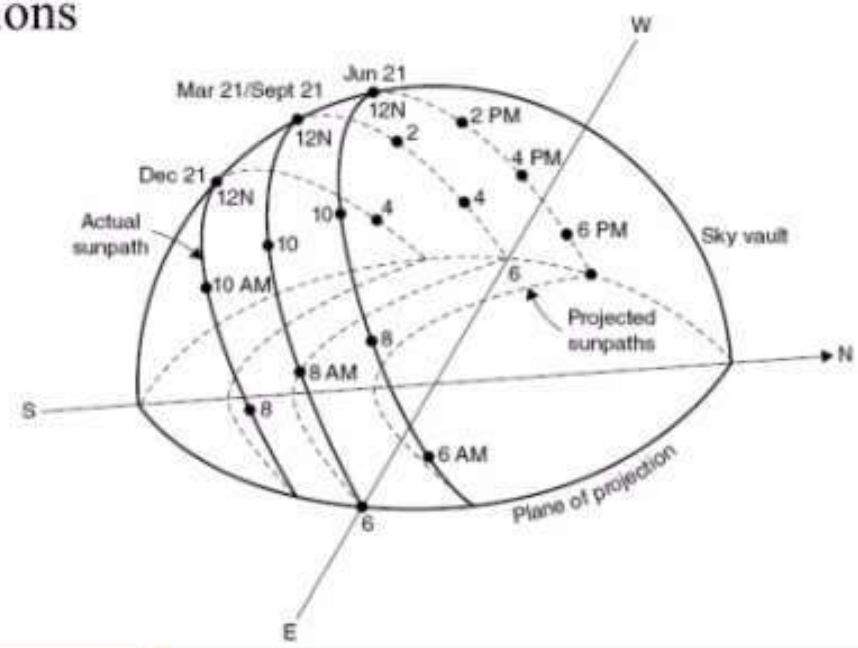
- Earth rotates around sun in elliptical orbit once every year & about own axis every 24 hours
- Due to tilted axis of rotation, different locations experience different solar intensity & different hours of sunlight
- The climate of earth is driven by the energy input from the sun.

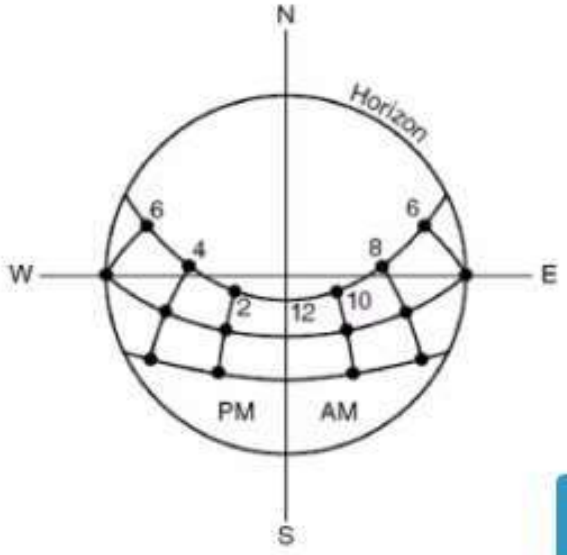


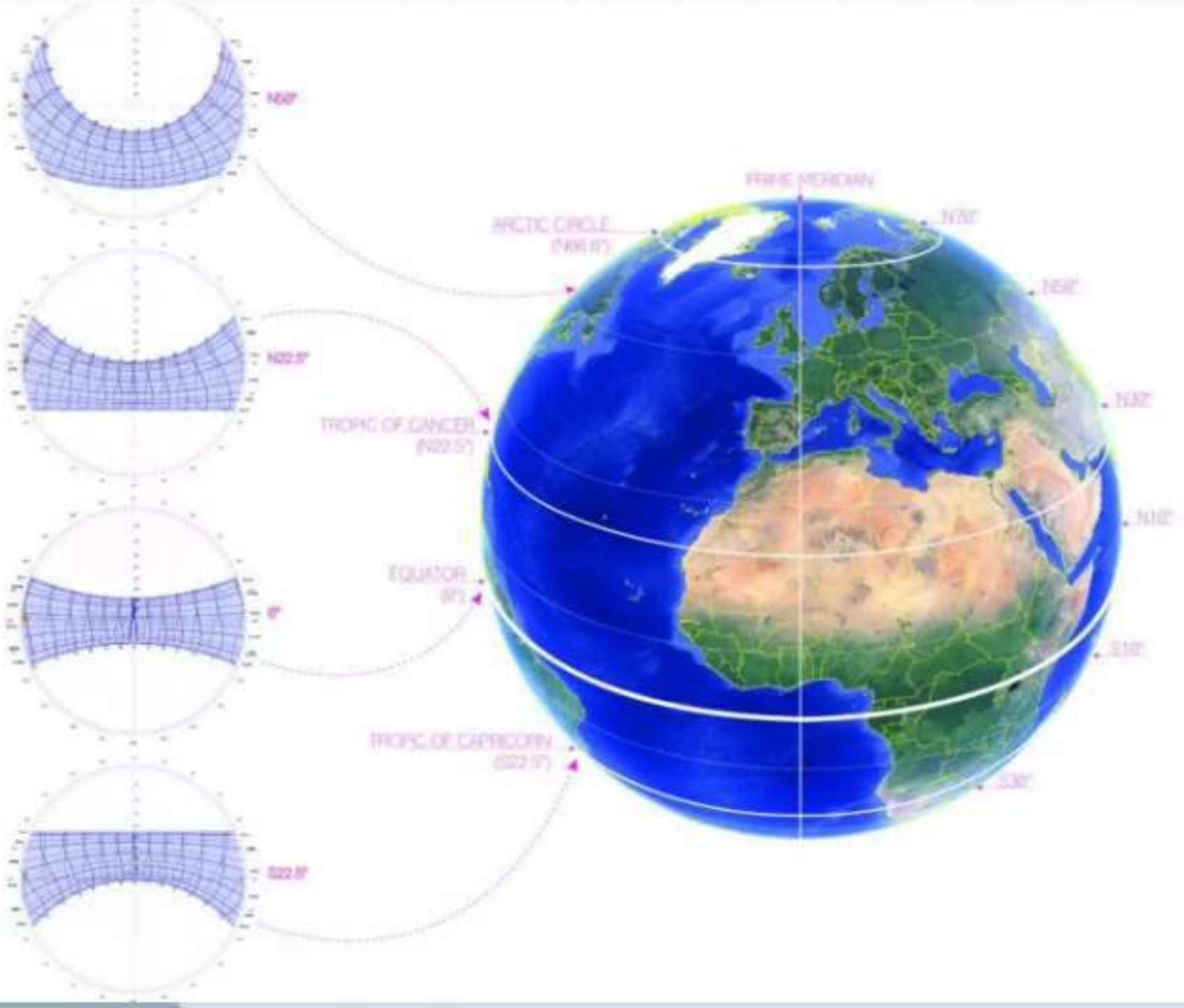


SUN-PATH PROJECTIONS

- We can identify how building will be sunlit and intensity of radiation at different times of day and different months.
- Stereographic diagrams are useful way to identify sun position and to understand the implication of solar radiation on surfaces of different orientations






PRIME MERIDIAN
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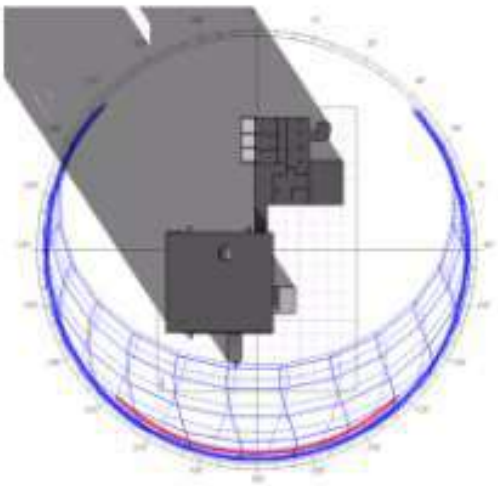
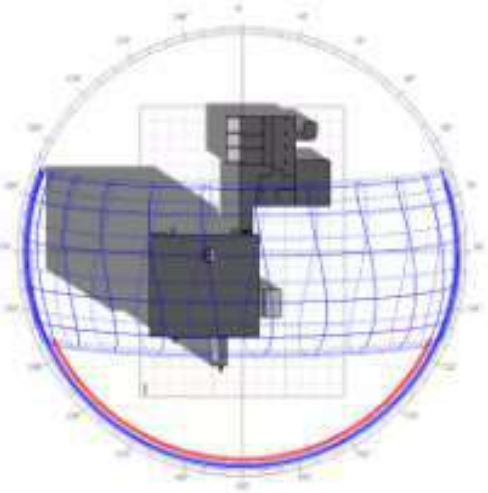
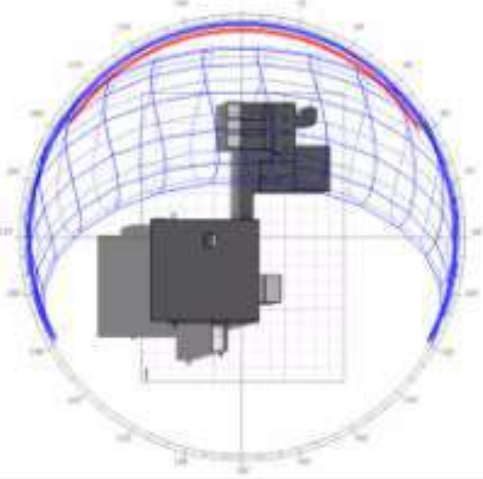
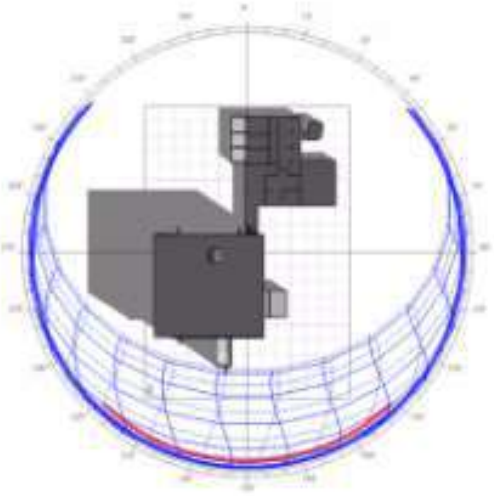
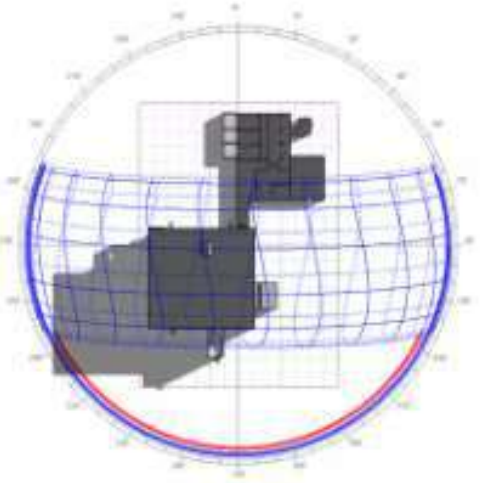
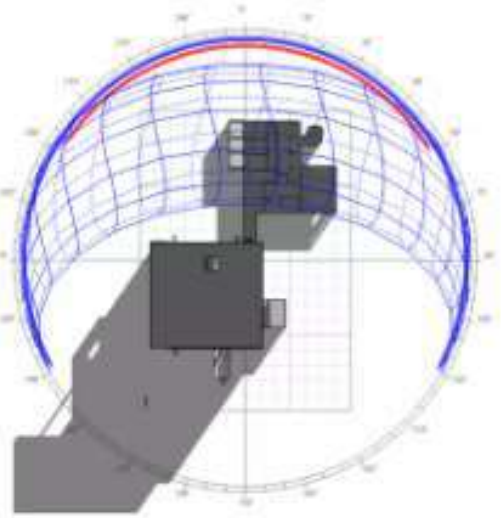
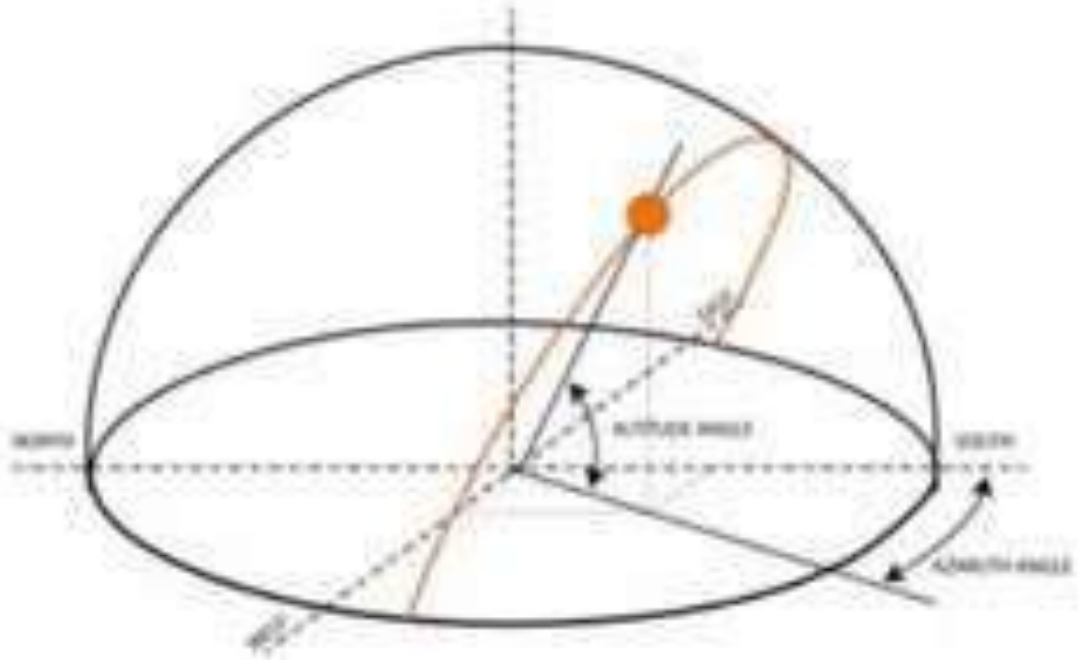
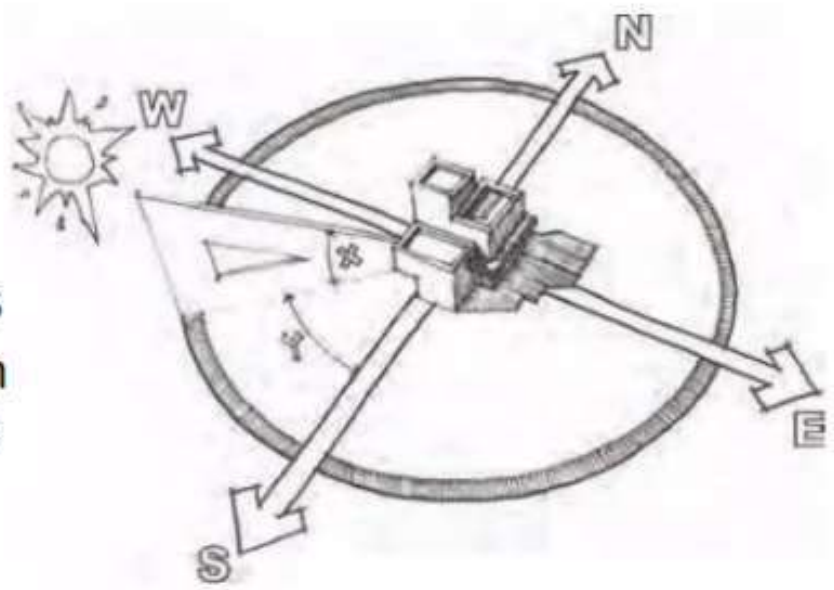
21 Dec @ 10am			
21 Jun @ 10am			



Solar altitude angle is the vertical angle between the horizontal and the line connecting to the sun. At sunset/sunrise altitude is 0 and is 90 degrees when the sun is at the zenith.

Azimuth angle is the angle within the horizontal plane measured from true South or North.

Position of the sun Altitude & Azimuth

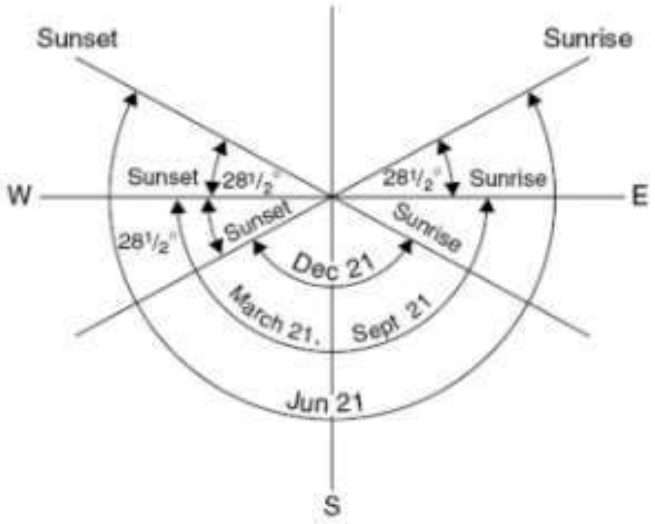


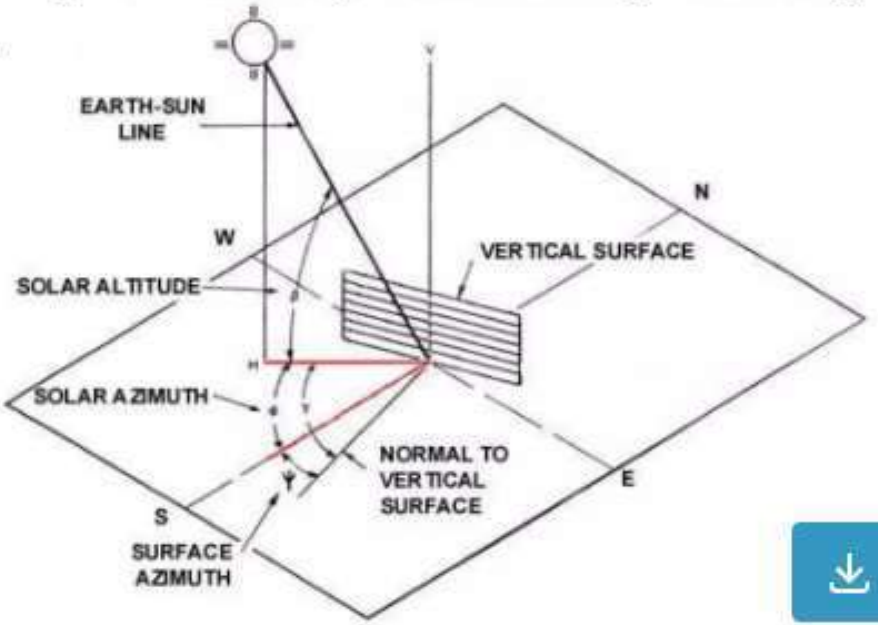
- Position of sun described by 2 angles
  - angle of altitude - vertical angle between horizontal ground plane & earth-sun line
  - angle of azimuth - horizontal angle of earth-sun line relative to north

angles determined using sun path diagram

Horizontal bearing angle from south

- The azimuth angle of the sun is dictated by the time of day and by the season.
- The principal significance of the azimuth angle is its role as an important consideration when orienting a building on a site, establishing building exposures, and analyzing shading angles.





SHADING DEVICES: INTRODUCTION

Shading windows from solar heat gain is a key design strategy for passive cooling and to reduce cooling loads on active HVAC systems.

Why Shading is very important?

- To prevent unwanted sun penetration in hot seasons, windows and other openings must be shaded.
- Provide protection against glare & direct sunlight into building

Shading for Orientation

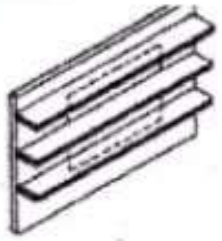
- Because of the high altitude of the sun, the most effective shading device for south-facing windows during the summer is a horizontal overhang.
- On east- and west-facing windows, a horizontal overhang is somewhat effective when the sun is at high positions in the sky, but is not effective at low-altitude angles.

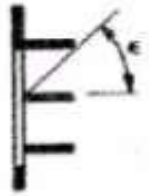
Types of External Shading Devices

- Classified as one or more of the following
  - Internal or External
  - Fixed or Adjustable

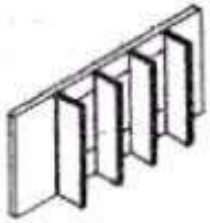
- External shading devices are most efficient. They can classified into:
  - Horizontal
  - Vertical
  - Egg-crate

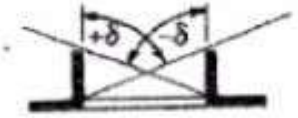
- horizontal



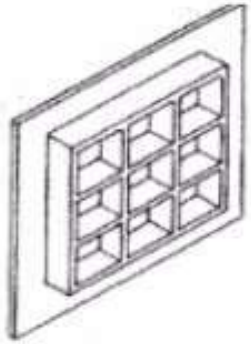


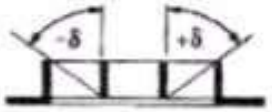
- vertical

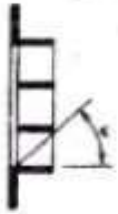




- egg-crate

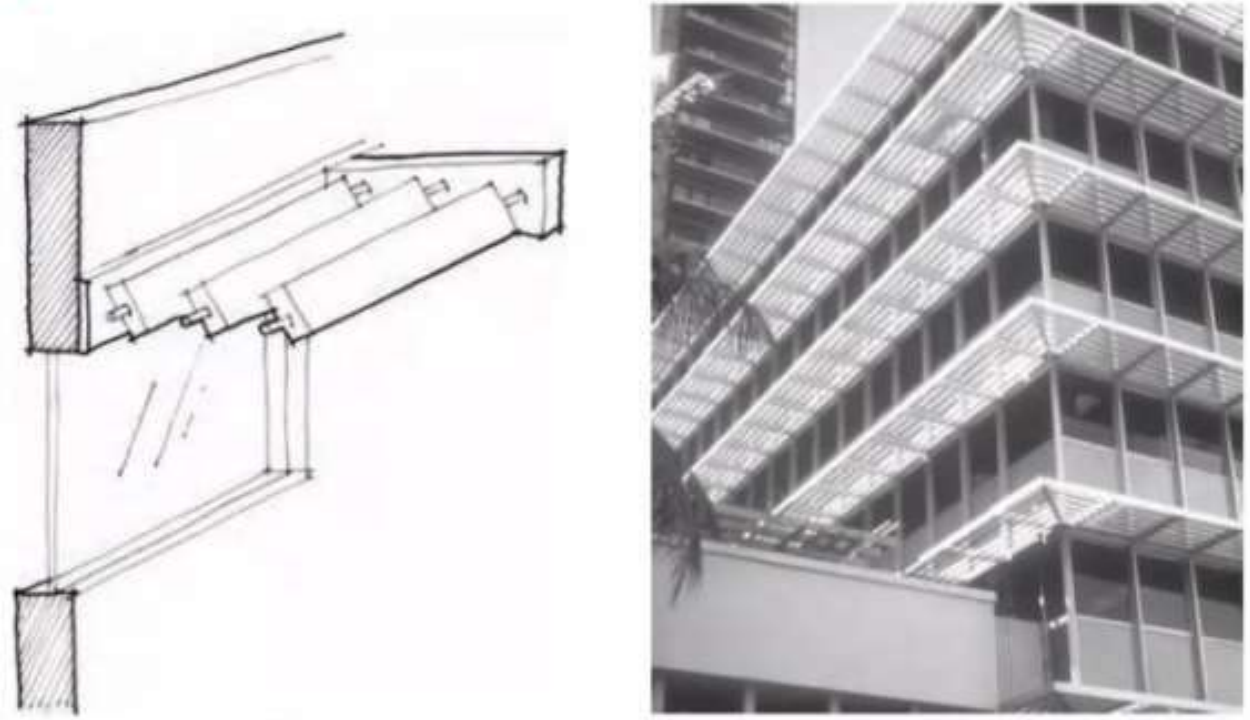






Types of External Shading Devices

Overhang with horizontal louvers.

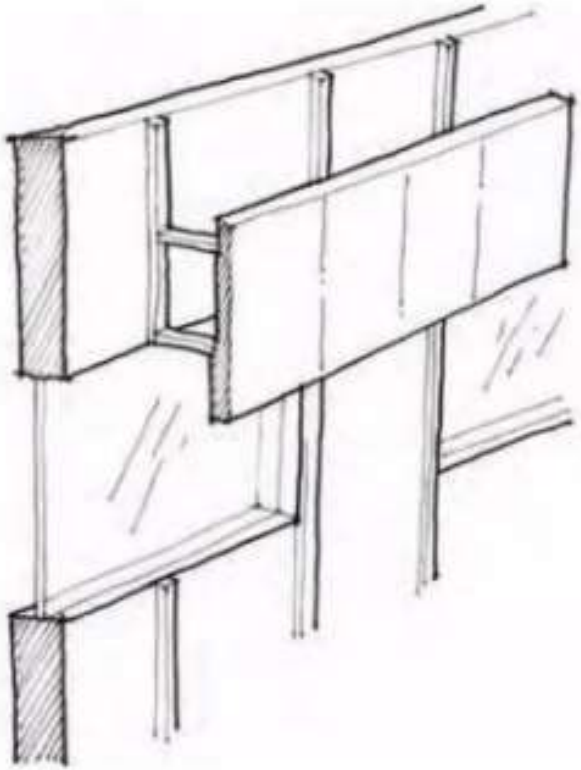


(a) (b)

(a) Overhang with horizontal louvers. (b) Horizontal louvers allow free air movement—office building in Honolulu, Hawaii.

Types of External Shading Devices

Overhang using a series of vertical panels.



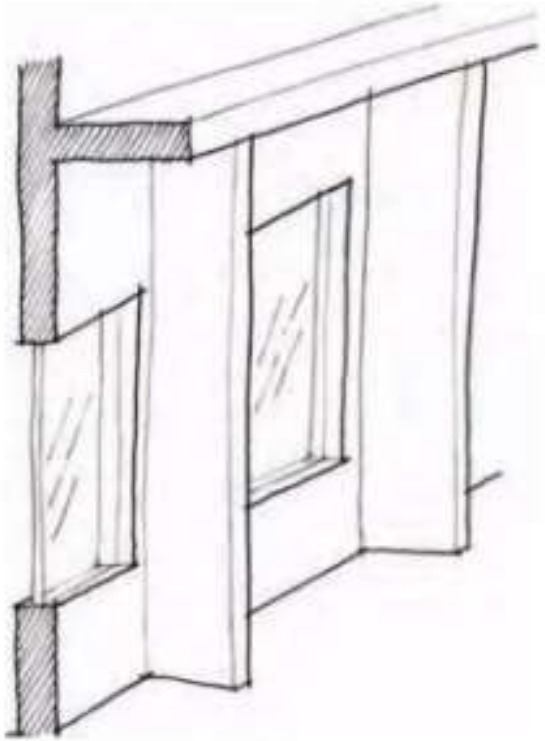
(a)

(b)

(a) Overhang using a series of vertical panels. (b) Application of horizontal overhangs at the IBM Tower in Kuala Lumpur, Malaysia

Types of External Shading Devices

Vertical fins



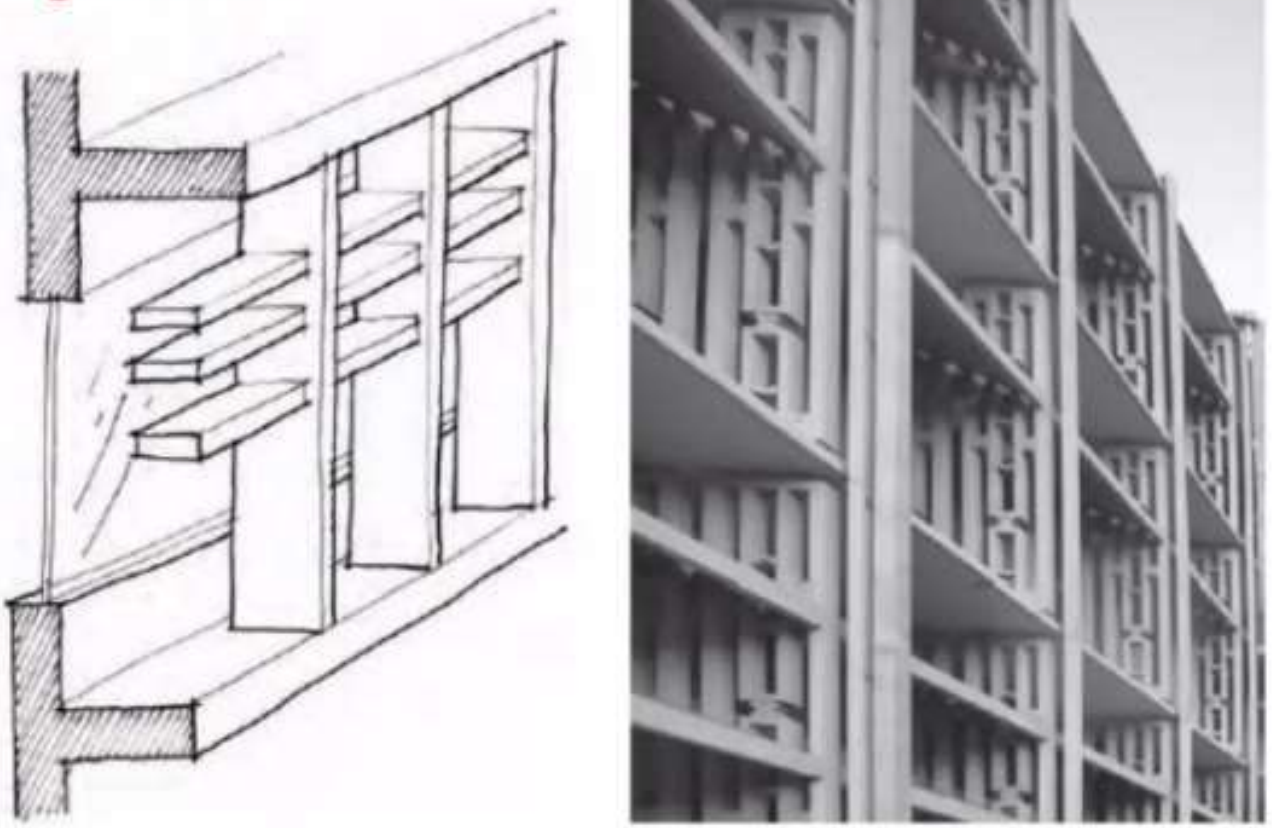
(a)

(b)

(a) Vertical fins. (b) Fixed vertical fins on a government building in Honolulu, Hawaii.

Types of External Shading Devices

Egg-crate shading device



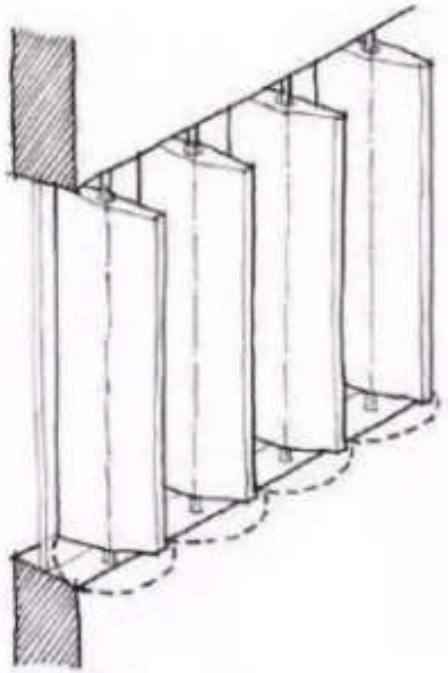
(a) (b)

(a) Eggcrate shading device. (b) Modified eggcrate to allow air movement and lighter structure at the Board of Water Supply in

Types of External Shading Devices

Movable (Operable) fins

Operable exterior shading devices are useful because they respond to daily and seasonal variations in solar and weather patterns in ways that fixed shading devices simply cannot do.



(a)

(b)

(a) Movable fins. (b) Movable fins are positioned according to the sun's position at the Ala Moana office building in Hawaii.

Design Considerations of Shading Devices

- Consider light surfaces can help bounce diffuse sunlight into the building. Diffuse daylight is ideal for providing lighting without glare.
- Consider a deep exterior wall section that can be used to self-shade the window surfaces with overhangs and vertical fins.
- Move the plane of the glass toward the interior plane of the wall to get free shading from the wall thickness.

Design Considerations of Shading Devices

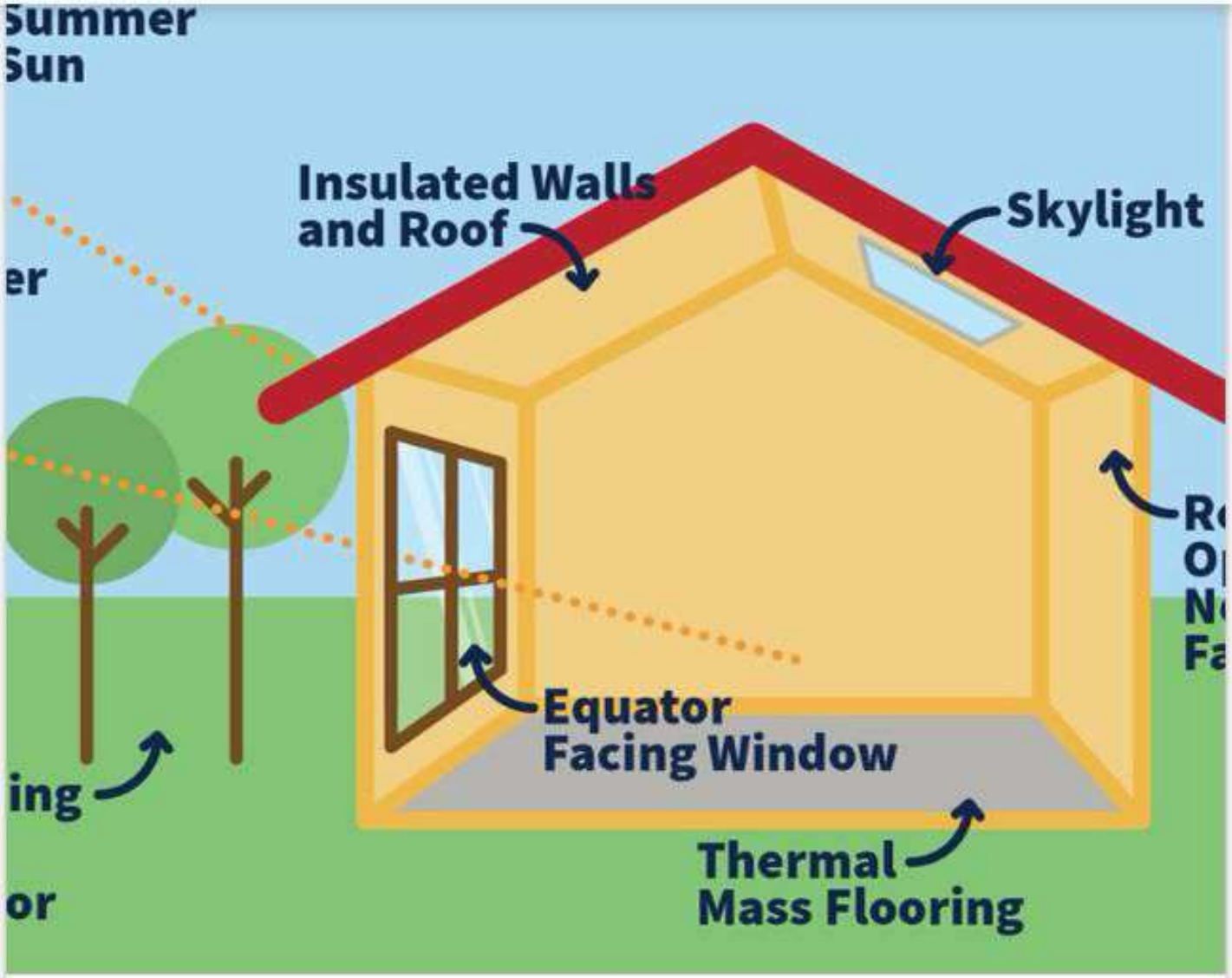
- Solar shading is most easily and effectively handled on south and north elevations.
- One method of describing the horizontal overhang is the ratio of the horizontal projection (x) to the height of the window (y) below the horizontal projection.
- Horizontal overhangs can adequately shade south-facing windows.
- In Najran for example, north-facing windows receive predominately diffuse solar radiation and indirect daylight, and therefore do not need overhangs.

Design Considerations of Shading Devices

- East- and west-facing windows are the most difficult to shade.
- Early morning and late afternoon sun rays are approaching perpendicular to these windows, causing excessive heat gain and visual glare.
- Minimize use of east- and west-facing windows.
- When these windows cannot be avoided, carefully size and place them for daylighting and view purposes only.
- Use a combination of horizontal louvers and vertical fins to shade these windows as much as possible.

Application of shading devices

East and west-facing windows need vertical shading devices



Solar Passive Design in Architecture

Welcome to the world of solar passive design in architecture. In this presentation, we will explore the principles, strategies, and benefits of this innovative approach to sustainable building design.

Principles of Solar Passive Design

1 **Orientation**

Design buildings to optimize solar exposure and minimize heat gain.

2 **Insulation**

Use high-quality insulation materials to reduce heat loss and gain.

3 **Ventilation**

Employ natural ventilation techniques to improve air circulation and reduce the need for artificial cooling.

4 **Shading**

Integrate strategically placed shading devices to prevent excessive heat gain during summer months.

Strategies for Solar Passive Heating

Thermal Mass

Utilize materials with high thermal mass to absorb and store heat during the day and release it at night.

Passive Solar Collectors

Install solar collectors such as roof-mounted water heating systems or thermal mass walls to capture and store the sun's heat for space and water heating.

Distributed Solar Heat

Ensure adequate insulation and minimize heat loss through well-sealed windows and doors.

Introduction to Solar Passive Design

Solar passive design is an architectural approach that utilizes the natural elements of the sun, wind, and land to create energy-efficient and comfortable buildings. Let's delve into the core principles of this design philosophy.

Strategies for Solar Passive Cooling

1

Passive Ventilation

Maximize natural airflow through the building using cross-ventilation, stack effect, and wind catchers.

2

Shading Devices

Implement external shading devices like overhangs, louvers, and awnings to block direct sunlight during hot seasons.

3

Night Purging

Utilize cool night air to ventilate the building and flush out accumulated heat.

Examples of Solar Passive Buildings

Sustainable Residential Home

Explore a solar passive residential home that seamlessly incorporates nature and sustainability into its design.

Eco-Friendly Office Building

Discover an innovative office building that uses solar passive strategies to reduce energy consumption and create a comfortable work environment.

Green Campus

Learn about an educational facility that showcases the potential of solar passive design in promoting sustainable practices.

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Conclusion and Future Possibilities

Solar passive design offers a plethora of opportunities for creating energy-efficient and comfortable buildings. Embracing this approach can lead to a sustainable future with reduced energy consumption and enhanced well-being. Let's continue pushing the boundaries of solar passive design and unlock its full potential.

Benefits of Solar Passive Design

Energy Efficiency

Significantly reduce energy consumption and reliance on traditional heating and cooling systems.

Comfortable Environments

Create naturally comfortable indoor environments by optimizing thermal, visual, and acoustical conditions.

Cost Savings

Lower utility bills and maintenance costs, leading to long-term financial benefits.

Sustainability

Contribute to a more sustainable future by reducing greenhouse gas emissions and environmental impact.

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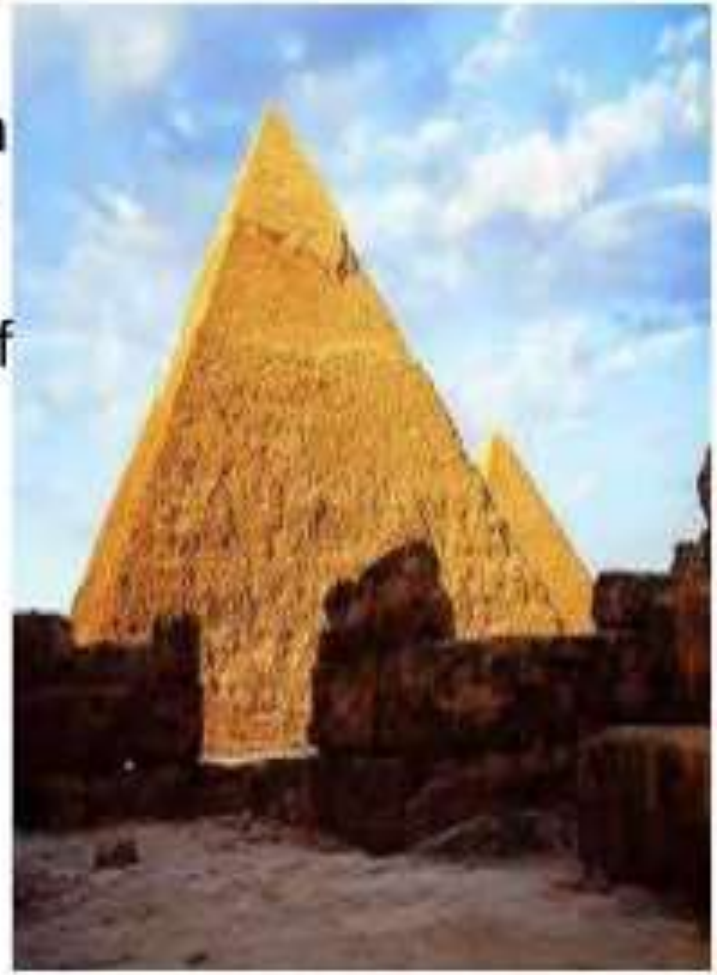
INTRODUCTION

Weather has a great impact on the structure and functionality of a building, it is of vital importance to choose building materials suitable for the weather.

Climate plays a significant role in the life span, durability and environmental performance of construction materials.

- Most historical places and ancient structures have been abandoned for many centuries but they remain standing to this day. This is due to the durability of their materials to stand up to the climate condition of the place where they are located.



- People in ancient times used construction materials and techniques to suit the weather conditions of the place for the intent to keep these places intact and survive for centuries as signs and symbols of their craftsmanship and hard work.

HOT AND DRY CLIMATE

- **General Characteristics :-**

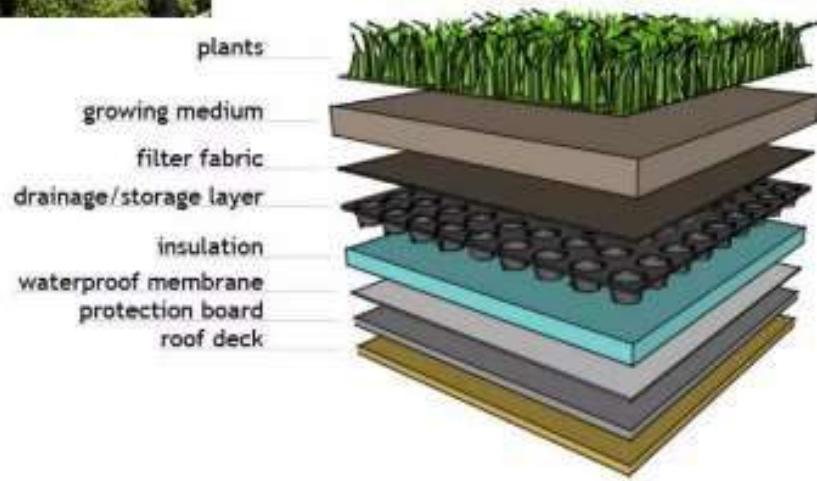
- Hot dry weather in summer and cold in winter.
- Very little rainfall and very low humidity.
- Sandy or rocky ground with very low vegetation cover.
- High temp. difference between night and day.
- Hot winds & frequent dust storms
- High summer day time temperatures(32-36° C)
- In hotter regions above 40 and up to 50°C.

MATERIAL FOR ROOFING

- Combinations of waste material (like paper tube) with clay tiles and ferrocrete and other alternative materials have better thermal performance as compared to tin sheet and RCC.
- Paper tube- CT, Lime roll-CT, Mud roll- CT, Lime roll-CT and Clay panel- CT are the four roof components which show minimum internal surface temperature .
- White Roofs:- A white roof is painted with solar reflective white coating and reflects up to 90% of sunlight.

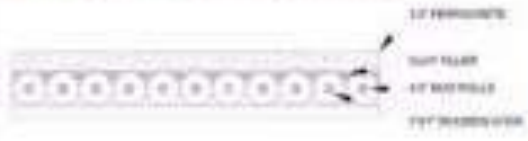
Green Roofs:-A **green roof** or **living roof** is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane

GREEN ROOFS

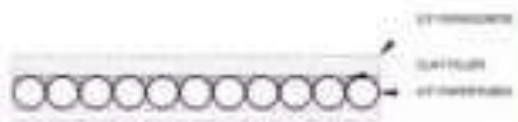


ROOFING WITH WASTE MATERIALS

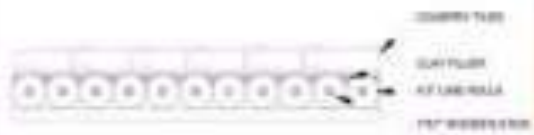
Module 1: Mud roll with Ferrocrete



Module 2: Papertube with Ferrocrete



Module 3: Lime roll with country tiles



Module 4: Mud roll with country tiles

Module 5: Paper Tube with Country tiles

Module 6: Concrete

Module 7: Tin Sheet

Module 8: Clay panel with Country tiles

•The huge massive stone is usually joint to a big basin to collect rainwater used to decrease of 6-7°C the interior temperature in summer.

•This allows the natural ventilation through the dome holes and is improved by the white color of the exterior surface made in lime

Walls And Flooring

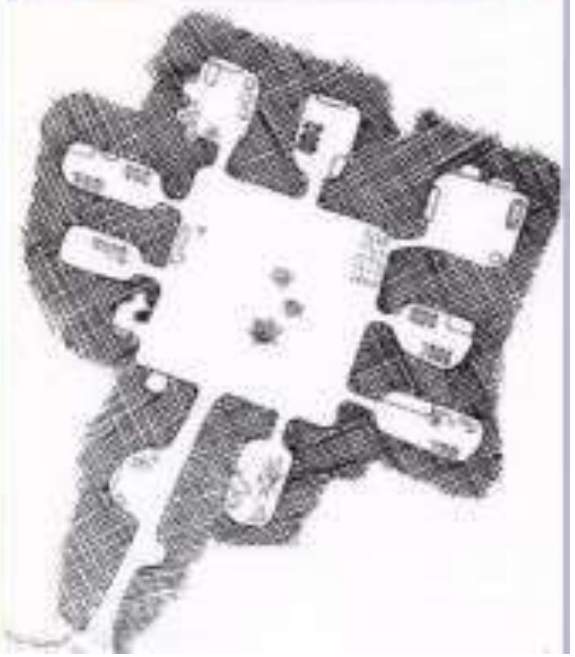
- The thick walls, made of mud, keep the interior cool when the temperature rises to 40 degrees Celsius in summer and warm when it beam and posts drops to 10 degrees in winter.
- Stone and tile flooring tend to perform the best in hot weather, requiring less maintenance and care than wood or bamboo flooring. That cool touch is a boon in hot climates

2. Arabic House

•The climate is so dry, the temperature range is so high, there's a strong solar radiation and the winds can transport huge amount of dust and sand.

• Houses placed around a big court dig into the rock: this court is the central point of the spaces distribution.

•Particular shape protects from the hot climate, but also from the dusty and sandy desert winds



HUMID CLIMATE

- General Characteristics:-

- Humidity remains high around 75% but varies from 55% - 100%.
- Wind

  Typically low wind velocity.
- Strong Precipitation

  2000 TO 5000 mm OF RAINFALL.

MATERIALS FOR HUMID CLIMATE

Roofs:- Majority of the buildings and homes is made of concrete. This is because concrete can withstand heavy rain downpours.

Sloped roofs are suitable for humid region

FLOORING

- Bamboo

A bamboo is layered flooring material. It has natural tendencies to expand and contract with temperature changes. Ideal as an alternative to solid wood in areas that are moist and humid.

COLD CLIMATE

- General Characteristics:-

- This climates have an average temperature above 10 °C (50 °F) in their warmest months, and a coldest month average below −3 °C (or 0 °C)

- The intensity of solar radiation is very low during summer and winter season.

MATERIAL FOR ROOFING

- **Choose a metal roof.** It's the most durable option, sheds snow with ease and rarely springs a leak. Metal roofs can shed snow so quickly.

- **Cement Tiles**

Concrete roofing tiles are extremely strong and capable of withstanding the most brutal weather conditions.

- **Solar Paneled Roofing**

Solar paneled roofing can be passive or active. Passive tiles are made of curved glass that captures rising hot air and guides it to the building's heating system They are UV resistant and extremely strong.

Active solar panels actually convert sunlight (photons) into electricity.

MATERIAL FOR FLOORING

- **Solid timber/Wooden flooring**:- It retains heat beautifully in cold climates and will give your home a warm and natural condition.
- **Carpeting Floor:-** It adds a bit of insulation, which adds comfort colder climates.
- **Tiles Flooring:-** It is best for all climate conditions
- **Choose easy-to-shovel flooring.** Gravel paths may look beautiful, but they are nearly impossible to shovel. Main paths should be made of hard material makes more sense.

MATERIAL FOR WINDOWS

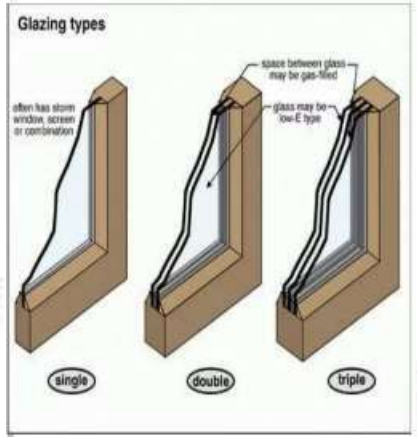
Window glasses form an important part of the windows.

Multi-pane windows rather than single-pane styles. Double or triple-pane windows are being used for saving energy consumption.

The vacuum created between the different panes works as insulating material and hence eliminates energy loss.

Insulating gases are often filled between the panes to reduce energy losses. Some of such gases used are argon, krypton.

Using low emissive glass panes which have a metallic oxide coating on the inner surface. The metallic oxide coating prevents the transfer of heat from warmer to colder climates.



Orientation of Building

Orientation of building is to **design building in such a way as it receives maximum ventilation and natural light in all climatic conditions.** It provides comfortable living conditions inside the house/building and saves energy bills also. The orientation can defend undesirable effects of worse weather. While planning to build a new house, ask your architect to design building in such a way **that energy loss is minimum.**

Climatic Implication

Orientation of building determines the amount of radiation the building receives. The orientation with respect to air patterns affects the amount of natural ventilation as much as possible.

Benefits of building orientation

Energy saving

Orientation of building is **energy efficient approach** as the building orientation saves heating, cooling and lighting cost. You can take optimal benefits of the sun by maximizing southern exposure. It lowers cooling cost by minimizing western exposure where it is most difficult to provide sunshade.

Breeze/Natural Air

Orientation of building provides breeze is in warm and humid climates. On the other hand, the orientation prevents hot winds in hot and dry climates.

Natural ventilation

Building orientation provides natural ventilation and light which is beneficial to the health of inhabitants of the house.

Factors Affecting Building Orientation

1. Solar radiation and temperature

The intensity of solar radiation depends on the direction of sunrays. The temperature of a structure and living space increases due to sun radiation and affects environment of the house. Solar radiation acts in two ways.

- Sunrays directly come to the house through openings
- Radiation comes indirectly through walls and roof of building by absorbing heat.

For comfortable living particularly during summer season, **radiation, temperature and treatment of room are considered.** From solar radiation point of view, the best orientation

is that which receives maximum solar radiation during winter and receives minimum solar radiation during summer season.

The **South façade has advantage of receiving more solar radiation** during winter than that of receiving during summer. Even for openings on south facade, small overhang such as curtains can cut off direct solar penetration during summer and allows it during winter. Obviously, this is most beneficial aspect, not available on any other façade.

How to minimize solar heat in south façade?

In fact the incidence of ground reflected radiation on human body from southern sun in south facade causes great thermal discomfort and visual glare. In northern India the South wall of a building or house receives least solar radiation during summer. To minimize reflected solar heat, grassy lawns should be developed in front of south façade.

How to minimize solar radiation in western façade?

The eastern and western façade receive nearly equal amounts of daily solar radiation throughout the year. The only difference is when the sun shines on eastern façade, the building or house is comparatively cool and air temperature is low. On the other hand due to higher air temperature in afternoon, the heat flows indoor through western façade. To minimize the affect of solar radiation in western façade, the sunshade on openings should be constructed.

2. Clouds and Rains

Clouds and rains have comparatively less importance in orientation of building. The areas with low clouds cover sky largely and determine the effect of both incoming solar radiation and outgoing terrestrial radiation. Glazing and opening should be designed keeping in view the direction of rain, beating the building because the direction of rain is generally same as that of prevailing wind except in case of storms. If due to architectural view glazing is provided, it should be covered by proper sunshade etc. The walls of lesser thickness should not be designed in the direction of heavy rains.

3. Humidity

It depends on weather condition of the area and has little role in orientation of building. The movement of air and use of prevailing wind are very important during periods of high humidity. Humidity can be classified into four categories i.e.

- **Very dry**
- **Dry**
- **Humid**
- **Very humid**

When humidity is low, dry or very dry, it is easy to take advantage of evaporative cooling in summer. When it is humid or very humid it is desirable to regulate the rate of air movement either artificially with aid of electric fan or with help of prevailing winds.

4. Humidity design consideration

The comfort in relation to humidity becomes complex. In humid environment there is very warm feeling when there is no breeze and air temperature is 30 0C. On the other hand if humidity is low, one may feel cool even if the temperature rises up to 32 0C with little breeze. It will be cooler at the same temperature if there is reduction in relative humidity. And if there is breeze in high humidity area, the building should be designed in such a way as it has more natural air and ventilation.

5. Prevailing winds

Prevailing winds help create natural ventilation in a building and give more comfort during high humidity. During orientation of a building and designing doors and windows openings, the direction of wind flow should be considered. Fix windows and ventilators at proper location in building to provide maximum air and light. The height of windows has much concern about ventilation. Maximum air and ventilation can be obtained if the level of opening is at the level of occupancy.

Consider velocity and direction of wind for orientation

For the purpose of orientation, it is necessary to study velocity and direction of the wind at particular place throughout the year. It is better if the flow of wind is more in building during humid period than rest period of the year.

Close openings to avoid heat and glare in summer

One should take appropriate action during orientation of building so that the building provides maximum comfort. Where there is extreme heat in summer and it becomes necessary to close openings to avoid heat and glare, it would be helpful to orient buildings to face winds during humid months instead of facing prevailing wind which comes from some other direction.

Note: Ideal or desirable orientation may not be possible in each individual case due to various factors in every situation. In this age of advance technology in materials and mechanical aids, the lighting and ventilation can be obtained for living and working after deciding on orientation of building.

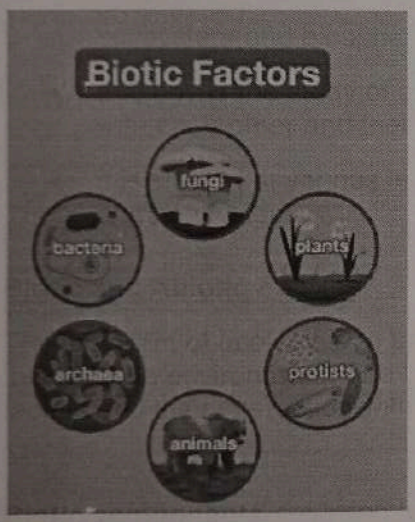
What is Ecology?

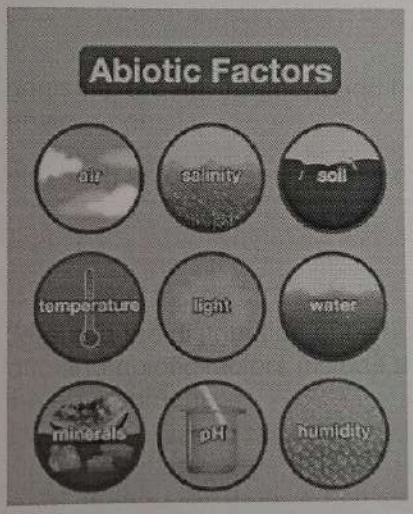
- Ecology is a branch of science, including human science, population, community, ecosystem and biosphere.
- Ecology is the study of organisms, the environment and how the organisms interact with each other and their environment.
- It is studied at various levels, such as organism, population, community, biosphere and ecosystem

Biotic and Abiotic Factors

The main aim of ecology is to understand the distribution of biotic and abiotic factors of living things in the environment. The biotic and abiotic factors include the living and non-living factors and their interaction with the environment.

Biotic components are living factors of an ecosystem. A few examples of biotic components include bacteria, animals, birds, fungi, plants, etc





Abiotic components are non-living chemical and physical factors of an ecosystem. These components could be acquired from the atmosphere, lithosphere and hydrosphere. A few examples of abiotic components include sunlight, soil, air, moisture minerals and more.

Living organisms are grouped into biotic components, whereas non-living components like sunlight, water, topography are listed under abiotic components.

The significance of Biotic and Abiotic Components

Biotic components can be classified into three categories:

Producers: These include all the autotrophs. They use light energy and synthesize food on their own, e.g. plants, green algae, etc.

Consumers: These include all the heterotrophs that directly or indirectly depend on producers for their food. Consumers are further categorized as herbivores, carnivores, omnivores and parasites.

Decomposers: These include saprophytes which act on dead matter and decay them for their nutrition.

The relevance of biotic and abiotic components in an environment appears when they start interacting with each other. For example, biotic elements like plants provide food for other organisms. The soil is the abiotic element which supports the growth of the plants by providing nutrients and other essential elements. Biotic components depend on abiotic components for their survival and help in the formation of abiotic factors like soil, nutrients, etc.

An ecosystem is the structural and functional unit of ecology. It is a community of living organisms along with the abiotic components interacting together through energy flows and nutrient cycles

The many specialties within ecology provide us with information to better understand the world around us. This information also can help us improve our environment, manage our natural resources, and protect human health.

FUNCTION of An ECOSYSTEM

The functional attributes of the ecosystem keep the components running together. Ecosystem functions are natural processes or exchange of energy that take place in various plant and animal communities of different biomes of the world.

For instance, green leaves prepare food and roots absorb nutrients from the soil, herbivores feed on the leaves and the roots and in turn serve as food for the carnivores.

Decomposers execute the functions of breaking down complex organic materials into simple inorganic products, which are used by the producers.

Fundamentally, ecosystem functions are exchange of energy and nutrients in the food chain. These exchanges sustain plant and animal life on the planet as well as the decomposition of organic matter and the production of biomass.

All these functions of the ecosystem take place through delicately balanced and controlled processes.

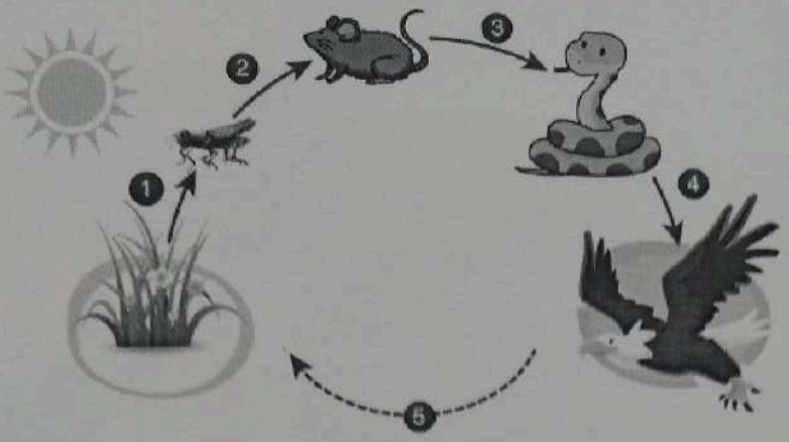
Important Ecological Concepts

1. Food Chain

The sun is the ultimate source of energy on earth. It provides the energy required for all plant life. The plants utilise this energy for the process of photosynthesis, which is used to synthesise their food.

During this biological process, light energy is converted into chemical energy and is passed on through successive trophic levels. The flow of energy from a producer, to a consumer and eventually, to an apex predator or a detritivore is called the food chain.

Dead and decaying matter, along with organic debris, is broken down into its constituents by scavengers. The reducers then absorb these constituents. After gaining the energy, the reducers liberate molecules to the environment, which can be utilised again by the producers.



Food Chain

1. The grasshopper eats the plants
2. The mouse eats the grasshopper
3. The snake eats the mouse
4. The eagle eats the snake
5. When the eagle dies, fungi break down the body and turn them into nutrients

Food Web

Food web is a network of interconnected food chains. It comprises all the food chains within a single ecosystem. It helps in understanding that plants lay the foundation of all the food chains. In a marine environment, phytoplankton forms the primary producer.

NATURAL CYCLES IN ECO SYSTEM

A natural process in which elements are continuously cycled in various forms between different compartments of the environment (e.g., air, water, soil, organisms).

Examples include the carbon, nitrogen and phosphorus cycles (nutrient cycles) and the water cycle.

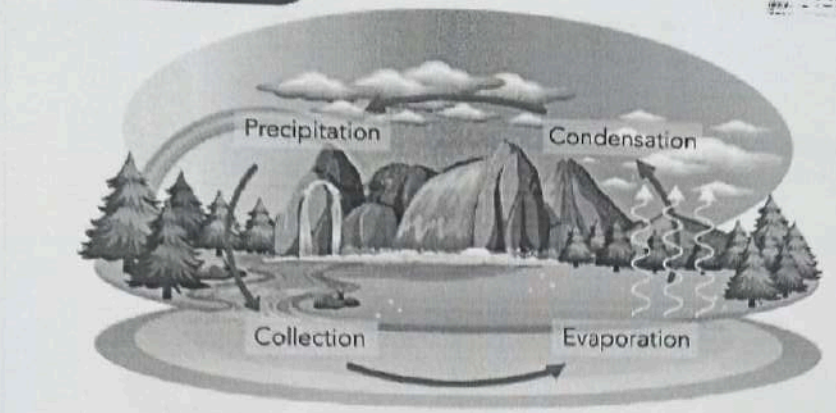
The three main cycles of an ecosystem are the

- water cycle,
- the carbon cycle and
- the nitrogen cycle.

These three cycles working in balance are responsible for carrying away waste materials and replenishing the ecosystem with the nutrients necessary to sustain life. If any of these three cycles should become unbalanced, the effects on the ecosystem can be catastrophic.

1 The water cycle *is a bio geological cycle that included a continuous circulation or flow of water through different phases of the ecosystem*

WATER CYCLE



Stages of Water Cycle

There are many processes involved in the movement of water apart from the major steps given in the above water cycle diagram. Listed below are different stages of the water cycle

Evaporation and Transpiration

Heat of the sun causes evaporation of water from rivers, lakes and the ocean. The water vapor formed rises and mix up with air. Evaporation is an important part of the water cycle and occurs continuously throughout the nature.

Plants require water to make their food, which they obtain from the soil. Plants releases water from leaves which evaporates into the air.

Condensation

Water vapor evaporates from water bodies in the air, it condenses and changes into tiny droplets and then clouds are formed.

Precipitation

When these droplets become so dense and heavy, they come back to the earth in the form of rain, hail, sleet or snow. Precipitation is responsible for bringing back the fresh water on the earth.

Accumulation

When water falls back on earth, it gets collected in the ocean, lakes or river or under the ground.

Water is continuously recycled on the earth; from water bodies to the sky and down to land, to be transported back to the water bodies again.

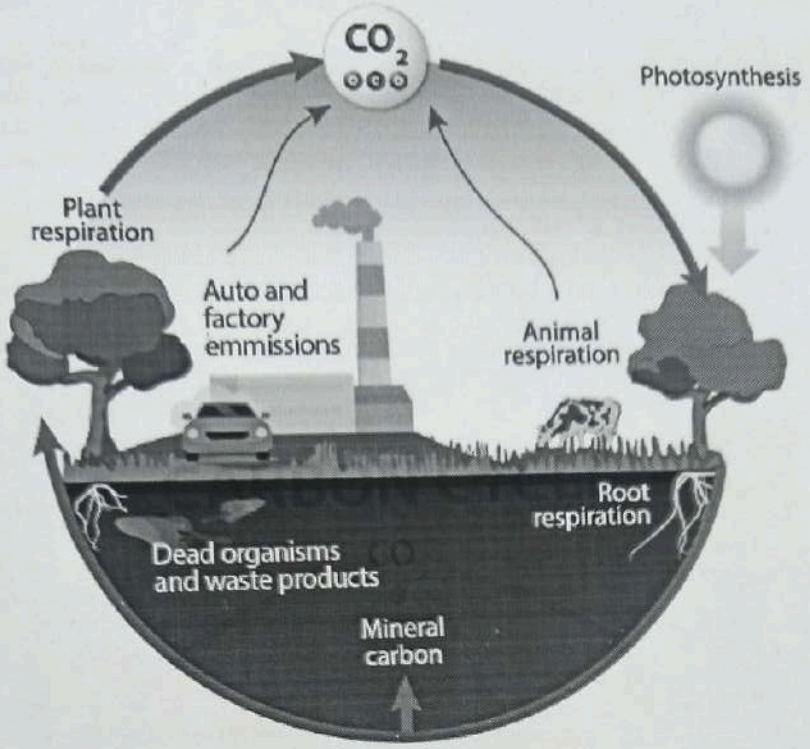
Importance of water cycle

We use water for drinking and for other purpose. We have limited water on earth and if the water did not come back to us through the water cycle then we would not have fresh water. So, we should use water judiciously and avoid wasting water.

2

Carbon Cycle

CARBON CYCLE



- The carbon cycle is a process where carbon dioxide travels from the atmosphere into living organisms and the Earth, then back into the atmosphere.
- Plants take carbon dioxide from the air along with water and photosynthesis from the sun and use it to make food.
- Animals then eat the food and carbon is stored in their bodies and released.
- Most of the carbon they consume is exhaled as carbon dioxide.
- The CO2 then is returned to the atmosphere where the plants use it again.
- When dead plants, animals, and animal waste break down or decompose, they also release carbon dioxide as well, known as methane.
- The carbon cycle is the Earth's ultimate form of recycling and is a delicate balance. Carbon dioxide is a greenhouse gas and traps heat in our atmosphere.
- Burning more fossil fuels has created more than 30% more carbon dioxide in the atmosphere than 150 years ago this is making the earth become warmer.
- Helping to keep our environment clean by burning fewer fossil fuels will assure this cycle keeps going for our future generations.

3

The Nitrogen Cycle

The nitrogen cycle describes how nitrogen moves between plants, animals, bacteria, the atmosphere (the air), and soil in the ground. Nitrogen is an important element to all life on Earth.

5

Different Nitrogen States

For Nitrogen to be used by different life forms on Earth, it must change into different states. Nitrogen in the atmosphere, or air, is N_2. Other important states of nitrogen include Nitrates (NO_3), Nitrites (NO_2), and Ammonium (NH_4

Nitrogen Cycle

This picture shows the flow of the nitrogen cycle. The most important part of the cycle is bacteria. Bacteria help the nitrogen change between states so it can be used. When nitrogen is absorbed by the soil, different bacteria help it to change states so it can be absorbed by plants. Animals then get their nitrogen from the plants

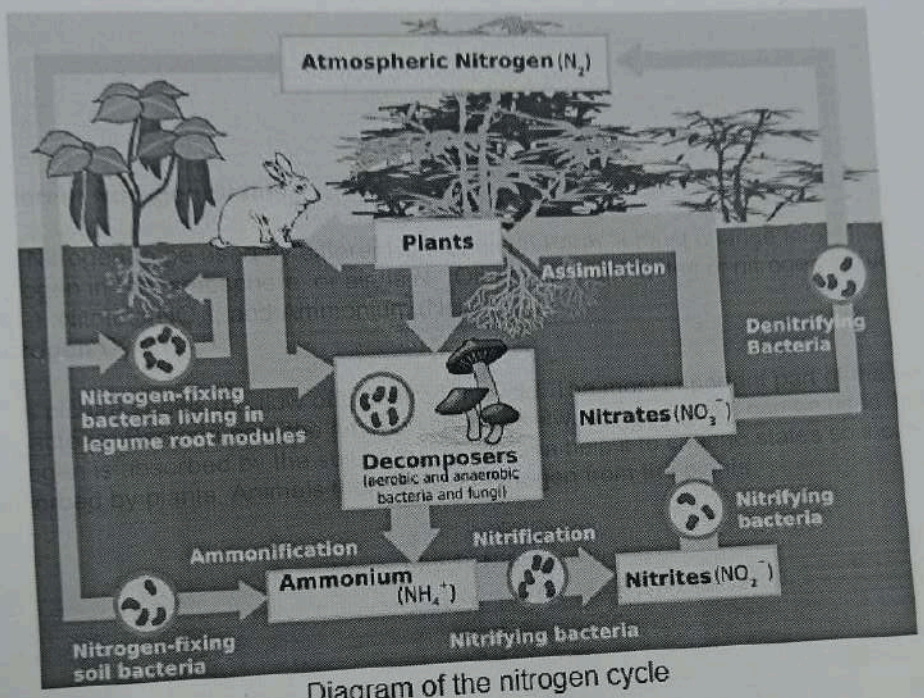


Diagram of the nitrogen cycle

Processes in the Nitrogen Cycle

- Fixation - Fixation is the first step in the process of making nitrogen usable by plants. Here bacteria change nitrogen into ammonium.
- Nitrification - This is the process by which ammonium gets changed into nitrates by bacteria. Nitrates are what the plants can then absorb.
- Assimilation - This is how plants get nitrogen. They absorb nitrates from the soil into their roots. Then the nitrogen gets used in amino acids, nucleic acids, and chlorophyll.
- Ammonification - This is part of the decaying process. When a plant or animal dies, decomposers like fungi and bacteria turn the nitrogen back into ammonium so it can reenter the nitrogen cycle.
- Denitrification - Extra nitrogen in the soil gets put back out into the air. There are special bacteria that perform this task as well.

Why is nitrogen important to life?

Plants and animals could not live without nitrogen. It is an important part of many cells and

processes such as amino acids, proteins, and even our DNA. It is also needed to make chlorophyll in plants, which plants use in photosynthesis to make their food and energy.

How have humans altered the nitrogen cycle?

Unfortunately, human activity has altered the cycle. We do this by adding nitrogen into the soil with fertilizer as well as other activities that put more nitrous oxide gas into the atmosphere. This adds in more nitrogen than is needed by normal cycle and upsets the cycle's balance.

Global Warming

Global warming is the process of Earth's average temperature increasing over a long period of time. Global warming is one of the most pressing environmental issues we are currently facing.

What causes global warming?

Greenhouse gases are the biggest factor contributing to global warming. It's important to know that many of them occur naturally in the atmosphere. In fact, without greenhouse gases, scientists estimate that the global temperature would be -18 °C.

However, human activity is causing a lot more greenhouse gases and as a result, the earth's temperature is increasing by too much. Here are just a few examples of how humans contribute to their increase:

1. Pollution - Fossil fuels such as coal, gas and oil are used to make electricity and run cars. These fossil fuels are burnt in power stations and as a result, carbon dioxide is released into the air. Carbon dioxide is a greenhouse gas, and it's very harmful to the environment.
2. Deforestation - Huge areas of trees are being cut down for different reasons, such as using wood for fuel, building houses or factories. This contributes to global warming as there are fewer trees left to absorb carbon dioxide in the air.
3. Agriculture and Farming - We need food to survive, so farming is very important for us. However, animals such as cows, sheep, pigs and chickens release a greenhouse gas called methane, which is very harmful to the environment. To feed these animals, farmers use fertilisers and pesticides to help plants grow well. These cause even more greenhouse gases to be released.
4. Water Vapour - Most water vapour ends up in the atmosphere in a natural way - for example, when water evaporates from the oceans and seas. However, human activities such as power plant cooling and flying can contribute to the creation of this greenhouse gas as well.

What are the effects of global warming?

Global warming is affecting life around the world and as a result, nature and wildlife are having to adapt to the new changes. Here are some of the effects of global warming:

- Ice is melting at the North and South Poles, causing a lot of animals such as polar bears, seals and penguins to lose their habitat.
- The sea level has been rising more quickly over the last century. This can cause floods and endanger the lives of people living on the coast.

- We're experiencing more extreme weather events, including storms, hurricanes and tornadoes. These are dangerous and they can injure people.
- We're starting to experience hotter temperatures. This can cause droughts and result in less water and food for people.
- Trees and plants are flowering much earlier in the year.
- Animal species are becoming endangered

What can I do to stop global warming?

Stopping global warming isn't going to happen overnight. However, there are simple steps each of us can do to reduce our greenhouse emissions. It doesn't mean we have to change our lives completely! Here are a few simple changes, which we can try and add to our everyday life:

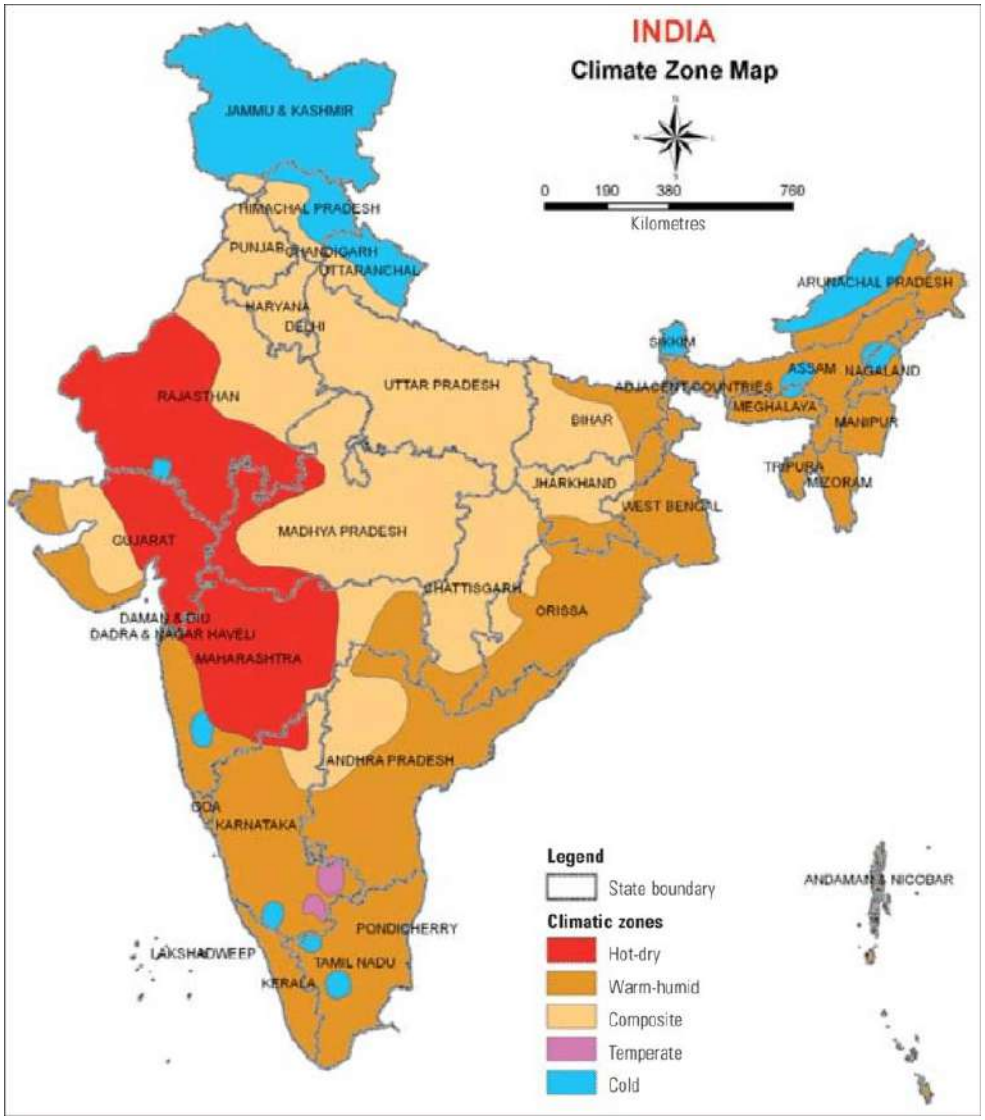
- Let's use less electricity. Turning off the lights and the TV when leaving the room is a great starting point.
- Let's use less water. Having a quick shower instead of a bath is better for the environment.
- Let's recycle. Try to recycle as much rubbish as possible. If things are recycled, factories don't have to make as many new things. This means factories will burn fewer fossil fuels.
- Let's use less plastic. Reusing shopping bags is a great way to stop the production of plastic. Plastic is very harmful to the environment as it takes thousands of years to decompose.
- Let's cycle/walk more instead of using motor vehicles. Taking fewer car journeys will result in less air pollution and less petrol being produced.
- Let's plant trees. Planting trees will not only help the air but wildlife, too. Try planting one in your garden or at a park nearby.
- Let's use public transport when needed instead of driving. When 20 people take the bus instead of using their cars, that's 19 fewer vehicles on the road!
- Let's buy locally-grown food. Shops often sell food, which has been transported on aeroplanes from the other side of the world. In the process, lots of carbon dioxide is released into the atmosphere. Buying locally is much more environmentally friendly.

Climatic Zones of India

Introduction

♦ Regions having similar characteristic features of climate are grouped under one climatic zone.

According to a recent code of Bureau of Indian Standards, the country may be divided into five major climatic zones:



1) **Hot & Dry** (mean monthly temperature >30 and relative humidity <55%);
2) **Warm & Humid** (mean monthly temperature >25-30 and relative humidity >55-75%);
3) **Temperate (**mean monthly temperature 25-30 and relative humidity <75%);

4) **Cold** (mean monthly temperature<25 and relative humidity-all values)
5) **Composite** (This applies, when six months or more do not fall within any of the other categories)

Orientation of building should be done for the climatic zone in which the building is situated. The purpose of orientation is to provide residents a comfortable living space throughout the year even under severe undesirable weather conditions.

Buildings in different climatic zones require different passive features to make structures energy-efficient. Some features that can be adopted in particular zones are listed below.

1. Hot and dry climatic zones: Hot and dry climatic zones generally occur at This climatic condition generally occurs at latitude between 15 degrees to 30 degrees on both the hemispheres. Maximum daytime summer temperature goes as high as 45 degree centigrade and relative humidity as low up to 20 %.

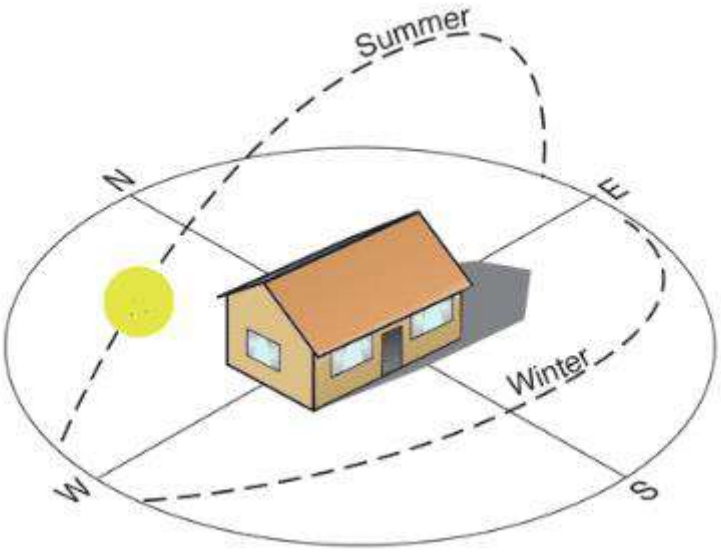
This type of climate is experienced in areas far from sea coasts and do not receive heavy rainfall. Thus, the humidity is very low. So, the buildings in this climatic zone should be orientated based on solar point of view so that the building receives maximum solar radiation during winter season and minimum radiation during summer season.

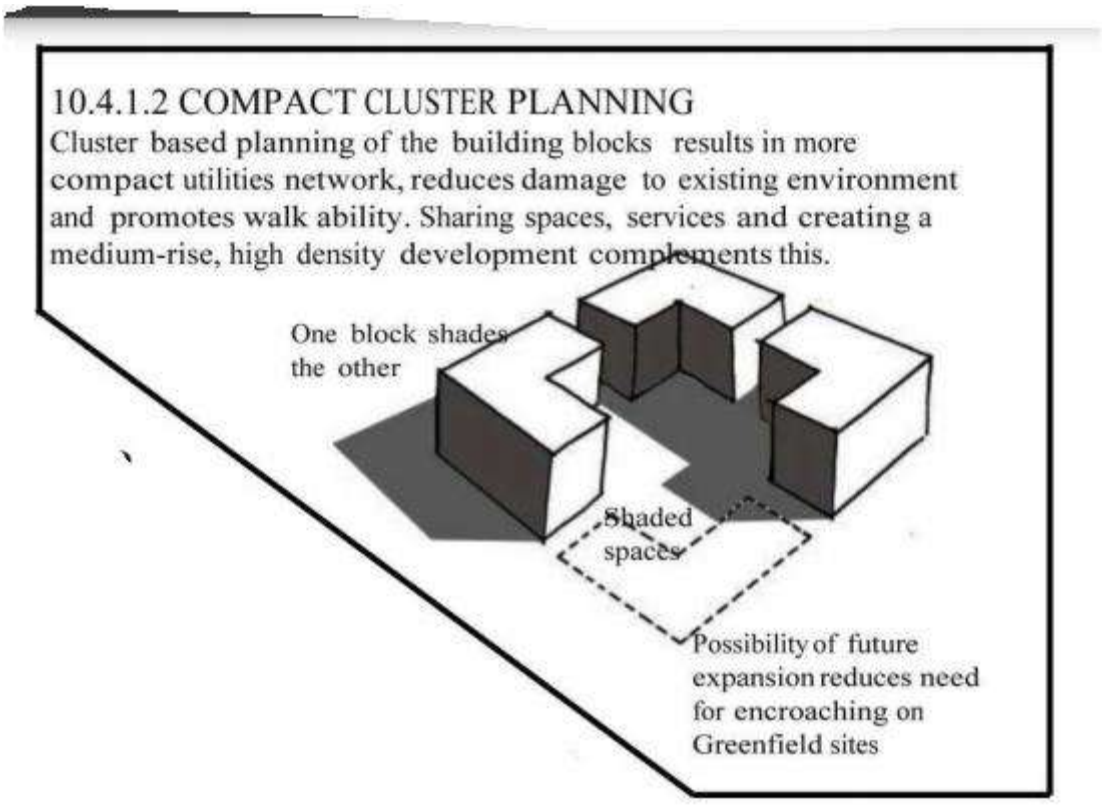
Climatic of the hot and dry region are:
1. Hot dry in summer and cold in winter
2. Very little rainfall
3. Very low humidity
4. High temperature difference between night and day
5. Hot winds and frequent dust storms
6. High summer day time temperature (32-36 c)
7. High direct solar radiation
8. Clear sky most of the year
9. Sandy or rocky ground with very low vegetation cover

Desirable features of buildings in hot and dry climatic zones are:

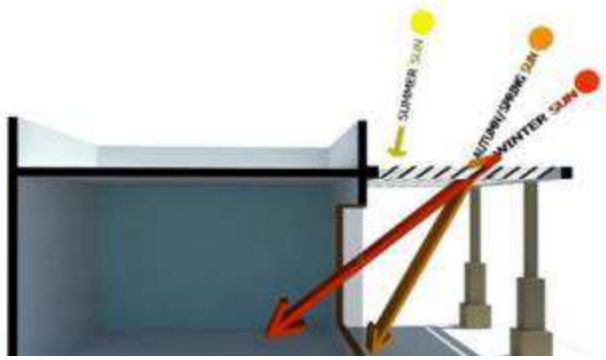
1. Orientation of building: Orientation of building in this climatic zone should be such that non-habitat rooms can be located on outer faces to act as thermal barrier.

Longer walls of building should face North & South so that the building gets minimum solar exposure. Preferably the kitchen should be located on leeward side of the building to avoid circulation of hot air and smell from the kitchen.





2. Windows and Openings in Walls: Windows and large openings in walls with heavy shutters should be provided on northern and western faces as light coming from north is always diffused and indirect. Also direction of breeze, which is from west at most of the places, enters from opening on west side. Windows area should be 15 to 20 percent of floor area.



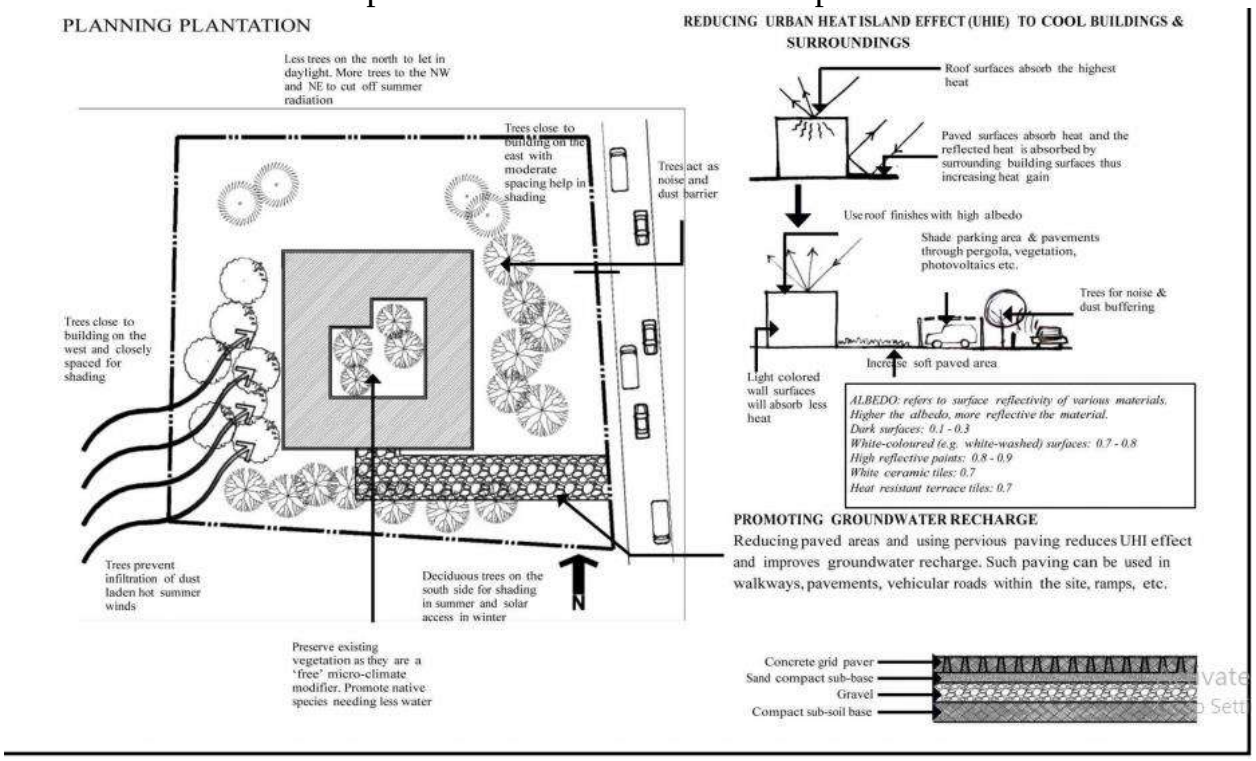
Internal courtyard caters for cross ventilation & thermal buffer. Suitable radiation barriers in the form of canopies, Chajjas, long verandahs etc. should be provided on the West side of the building. Sufficient number of ventilators close to the bottom of slab should be provided for hot air to escape the room.

3. Orientation of Walls: Thickness of wall plays an important role in heat insulation of building. Thicker outer walls are preferred as it behaves as an insulating barrier. Painting of walls from outside also plays an important role. Walls with light and shining paints on outer surface have good reflective quality and do not absorb heat. The surface of walls should be smooth and non-dust catching type.

Walls constructed with hollow blocks / bricks and **Cavity Walls** can also be provided as they provide very good thermal insulation.

4. Insulation of Roofs: Roofs should be built up with good insulating material having slope in windward direction and which reflects the radiation and does not absorb heat. False ceiling can be used to improve thermal performance of building. Terracing should be provided on the flat roof with mud phuska, lime concrete, foamed concrete or burnt clay block paving over roof slab. Top roof surface should be made reflective by providing whitewashing or any reflective paint.

5. Growing of Vegetation: Large shady trees whose roots do not strain foundation and basement should be planted near external walls to provide shade.



6. Special Building Orientation Requirements: Outdoor sleeping area for summer nights preferably is provided. Desert coolers and fans can be used during summer months. Therefore, proper space to provide coolers should be planned in the building.

7.Landscaping

Landscaping is an important element in altering the microclimate of a place. Proper landscaping reduced direct sun from striking and heating up building surfaces. It is the best way to provide a buffer for heat, sun, noise, traffic, and airflow or for diverting airflow or exchanging heat in a solar-passive design.

Fig. 7. Landscaping

It prevents reflected light carrying heat into a building from the ground or other surfaces. Deciduous trees provide shade in summers and sunlight in winters; hence, planting such trees on the west and southwestern side of the building is a natural solar passive strategy. On the other hand, evergreen trees on the north and north-west of the building provide shade round the year. The use of dense trees and shrub plantings on the west and southwest sides of a building will block the summer setting sun.

Fig. 8. Natural cooling

CONCLUSION

BUILDING DESIGN:

1. Detailing building fenestration design and **construction** details to promote shading, heat loss and insulation.
2. Larger building dimensions should face north & south.
3. Double walls with insulation in between are a suitable solution

4. The size of the windows on the east and west sides should be minimized in order to reduce heat gain
5. The flat roof is a good reflector and re-radiates heat efficiently, especially if it consists of a solid, white painted material.
6. The courtyard is provided with water and plants, it acts as a cooling source.
7. Internal courtyards provide cross ventilation and natural cooling.
8. Inlets to be provided at lower levels and outlets at a higher level as they serve to vent the hot air.
9. Suitable radiation barriers in the form of canopies, chajjas, and long verandahs should be provided on the west side of the **building**.

- Madhya Pradesh – **The places which have a** hot and dry climate **in MP is Gwalior, Jabalpur, Sagar, Rewa, Singrauli.**

- Gujarat – **Ahmadabad is the capital which has the maximum hot and dry climate throughout summer.**

- Andhra Pradesh – **Vijayawada, Khammam, Thallarevu (East Godavari) are some of the southern places in AP.**

d) Color & Texture

* The walls should be painted light pastel shades or whitewashed, white surface of the roof be of broken tile to reflect sunlight back to the environment, and hence reduce heat gain.
* The surface finish should be protected from effects of moisture.
* The use of appropriate colors & surface finishes is a cheap & very effective technique to lower indoor temperature

Material

- The natural building materials available for construction in Kerala are stones, timber, clay and palm leaves.
- Granite is a strong and durable building stone; however its availability is restricted mostly to the highlands and only marginally to other zones.
- Lime mortar can be improved in strength and performance by admixtures of vegetable juices.
- Such enriched mortars were used for plastering or for serving as the base for mural painting and low relief work.
- Timber is the prime structural material abundantly available in many varieties in Kerala - from bamboo to teak.
- Clay was used in many forms - for walling, in filling the timber floors and making bricks and tiles after plugging and tempering with admixtures.
- Palm leaves were used effectively for thatching the roofs and for making partition walls

The most common materials used for building walls in the warm-humid regions are stones, and earth-based bricks.
Traditionally, earth-walled courtyard houses are typical with broad overhanging eaves to shade the exterior walls.

3. COMPOSITE—NEW DELHI, ALLAHABAD, KANPUR

CLIMATE DETAILS • Cloudy days:8-10 days in a month • Clear skies:20-22 days in a month • Average wind speed: 3-5 km/h • The intensity of solar radiation is very high in summer with diffuse radiation amounting to a small fraction of the total. • In monsoons, the intensity is low with predominantly diffuse radiation.
This region receives strong winds during monsoons from the south-east and dry cold winds from the north-east. • In summer, the winds are hot and dusty • The sky is overcast and dull in the monsoon, clear in winter and frequently hazy in summer. • The presence of high humidity during monsoon months is one of the reasons why places like New Delhi and Nagpur are grouped under the composite and not hot and dry climate.

- In Delhi climate, buildings should be oriented in such a way that its longer axis should remain in east -west direction. In this orientation, the walls will receive less solar radiation in summer and more solar radiation in winter in comparison to other orientations. This orientation minimizes the heat load in summer and is a very effective passive cooling strategy.

- The walls should be thicker having time lag over 8 hours.
- Cavity walls or composite walls are also very helpful in controlling the heat transfer from outside to inside the building.
- When the air movement is necessary, the advantage of prevailing breeze should be taken by grouping the buildings in relation to the wind direction.
- Fenestrations should be made on the walls perpendicular to the wind direction.
- Direct sunlight must be excluded from the fenestration and window shades should be designed in such a way so that it cuts the summer sun but permits winter heat inside the building.
- Roofs should also be properly insulated so as to minimize heat transfer from the roof to the inside of the building.
- Provision of adequate rainwater drainage is also essential in this climate

STONE and CONCRETE

4. TEMPERATE

Temperate climate is characterized by temperatures which are neither too hot nor too cold. The total rainfall usually exceeds 1000 mm per year. Winters are dry in this zone.

This climate requires a building design which would reduce heat gain by providing shading, and promote heat loss by ventilation.

A good ventilation system can easily provide comfortable standards.

Wind direction- South to north

the building generally sited with longer facades orienting towards the North and South to reduce the heat gain from East and West and benefit the glare free sunlight available on the North.
On the south, a two layered wall with a cavity serves as insulation from the southern sun and heats the air within the cavity.
The hot air in the cavity rises up, known as chimney action, pulling in fresh air from the north.
Another feature "Breeze wall" forces predominant wind to the space and create air changes due to pressure difference. These buoyancy driven techniques are very effective means of keeping the building well-ventilated.
Intermediate courtyards and skylight running through the center of the building illuminates the heart of the building with natural light.
The skylights were made of tinted glass which reduces glare and make the environment visually comfortable.
The front façade (north wall) of the building with concrete louvers shade the wall and help in maintain lower indoor temperatures.
The roof was designed to be a roof garden utilizing the ground cover that was disturbed during construction. This reduces solar radiation and serves as insulation to the building.

Materials

The walls were constructed of fly ash concrete bricks, utilizing waste from the Steel Industry.
Coffered slabs were used instead of conventional ones to save concrete in terms of structural columns. Locally available Sadarahalli granite was used to make the paved area outdoor

MYSORE, BANGALORE(KARNATAKA)

5. COLD

Regions that lie in the cold climate zone are situated at high altitudes. The temperatures range between 20–30 ºC in summers; while in winters, it can range from -3 ºC to 8 ºC, making it quite chilly.

Cold climate requires buildings to have appropriate insulation and infiltration to resist heat loss, and promote heat gain by directly admitting and trapping solar radiation within the living space.

INTRODUCTION TO CLIMATOLOGY

- Climatology is simply the scientific study of the climates.
- Building Climatology is therefore the scientific study of climates with regards to the built environment. Buildings do not exist in isolation; they exist within a particular geographical context. Architecture as a scientific discipline seeks to ensure that the building and the contextual geographical environment are in a symphonic unity.If this is not achieved, the building will not yield maximum user comfort and will thus not fulfill its purpose.
- It is worthy to note that design mistakes of this nature are very expensive to remedy, if at all there is a remedy to it. On the other hand, the geographical characteristics of the environment can be harnessed to achieve maximum comfort and user experience.
- Weather is a sum total of atmospheric conditions of a relatively small geographical area in a short period of time.
- Climate on the other hand, is the sum total of atmospheric conditions observed in large geographical area over a long period of time.
- The period of this observation could be 25 -- 30 years. Hence, climate can be said to be an average of weather conditions taken over a long time.

CLIMATIC ELEMENTS AFFECTING THE BUILT ENVIRONMENT

There are five major climatic elements affecting the built environment. They are

- temperature,
- humidity,
- wind,
- atmospheric pressure
- and precipitation.

1. Temperature -is the degree of hotness or coldness of the atmosphere. Of all the other climatic elements, temperature is the most important because it influences the other elements. Temperature goes a long way to influence thermal comfort of the building.

Thermal comfort is the condition of the mind which expresses satisfaction with the thermal environment.The human thermal environment is not straight forward and cannot be expressed in degrees. Nor can it be satisfactorily defined by acceptable temperature ranges. It is a personal experience dependent on a great number of criteria and can be different from one person to another within the same space. For example, a person walking up stairs in a cold environment whilst wearing a coat might feel too hot, whilst someone sat still in a shirt in the same environment might feel too cold.

The factors affecting thermal comfort in buildings could be Environmental or Personal. Environmental in the sense that such factor surrounds you and may be beyond your control, or personal in the sense that you can directly influence the factors and control them.

Environmental factors affecting thermal comfort.

a) The temperature of the air that a person is in contact with could make the person feel hot or cold.

b) The velocity of the air that a person is in contact with (measured in m/s), could make exchange of heat between the person and the air faster, thereby giving the person a cooling effect.

c) Radiant temperature is the temperature of a person's surroundings (including surfaces, heat generating equipment, the sun and the sky). This too affects thermal comfort.

d) Relative humidity (RH) is the ratio between the actual amount of water vapour in the air and the maximum amount of water vapour that the air can hold at that air temperature. This is usually expressed as a percentage. The higher the relative humidity, the more difficult it is to lose heat through the evaporation of sweat. In such conditions, one's body will feel moist and sticky.

Personal factors affecting thermal comfort

a) Clothing. Clothes insulate a person from exchanging heat with the surrounding air and surfaces as well as affecting the loss of heat through the evaporation of sweat. Clothing can be directly controlled by a person (ie they can take off or put on a jacket) whereas environmental factors may be beyond their control.

b) Metabolic heat-The heat we produce through physical activity. A stationary person will tend to feel cooler than a person that is exercising.

c) Well being generally and sickness, such as the common cold or flu which affect our ability to maintain body temperature, 37C at the core.

Other effects of temperature on buildings

a) Thermal expansivity. Building components such as metals expand when hot and contract when cold. The higher the temperature rise in a building, the more the expansion of building components in that building. We may not readily see the effects of this due to the small of fraction of change that occurs, but over the years, the wear and tear will be evident.

b) Economic effect. The cost of mechanical Heating, Ventilation and Air Conditioning (HVAC) will normally rise with adverse effect of temperature rise or decline. During the hot season, mechanical ventilators and air conditioners are over worked which leads to the probable damage of these systems. The operational cost too and cost of repairs and servicing will be on the increase. Conversely, during the cold season, there may be attendant need to look alternative means of heating up indoor spaces; this too is will lead to further expenses.

2 Humidity- is the amount of water vapour in the atmosphere. It becomes Relative Humidity when a ratio is taken between the actual amount of water vapour in the air and the maximum amount of water vapour that the air can hold at that given air temperature. Like earlier said, it is usually given as a percentage. The effects of humidity can be seen as it effects thermal comfort. In a very humid environment, people will tend to sweat a lot, and clothes will not get dry easily after laundry.

3 Effects of wind on building

Wind is air in motion. It is caused by horizontal variations in air pressure. The greater the difference in air pressure between any two places at the same altitude, the stronger the wind will be. The wind direction is the direction from which the wind is blowing. A north wind blows from the north and a south wind blows from the south. The prevailing wind is the wind direction most often observed during a given time period. Wind speed is the rate at which the air moves past a stationary object.

Wind is the major component of ventilation in buildings. The pressure between the building envelope and the external environment differ, and that is why ventilation is possible. Adequate fenestration is required to harness this. Spread of communicable diseases is faster in poorly ventilated places.

In as much as wind is needed for ventilation, the adverse effect of wind on buildings can be quite detrimental. Prime of these adverse effect is that of wind-load on high-rise buildings. In the design and construction of high-rise buildings, the impact of wind-load must be taken into cognizance. Adequate provisions have to be made in the foundation design and the load-bearing framework of the buildings to ensure adequate strength and support against wind-load.

4. Pressure

Air is held to the earth by gravity. This strong invisible force pulls the air downward, giving air molecules weight. The weight of the air molecules exerts a force upon the earth and everything on it. The amount of force exerted on a unit surface area (a surface that is one unit in length and one unit in width) is called atmospheric pressure or air pressure. The air pressure at any level in the atmosphere can be expressed as the total weight of air above a unit surface area at that level in the atmosphere. Higher in the atmosphere, there are fewer air molecules pressing down from above. Consequently, air pressure always decreases with increasing height above the ground. Because air can be compressed, the density of the air (the mass of the air molecules in a given volume) normally is greatest at the ground and decreases at higher altitudes.

Whereas atmospheric pressure may not have direct effect on low-rise buildings, in the construction of very tall buildings such as sky scrapers, pressure becomes a serious part of design considerations. Alternative means (mainly mechanical) are sought to create a comfortable habitable pressure level. Except for surgical theatres where the room is to be maintained at a specific temperature, pressure and humidity, pressure is not too serious a part of design considerations for low rise buildings.

5. Effects of Precipitation and Vapour Pressure on buildings

Precipitation is the product of a rapid condensation process (if this process is slow, it only causes cloudy skies). It may include snow, hail, sleet, drizzle and rain. In our geographical context in northern Nigeria, as well as other parts of Nigeria, rain and fog are the most common form of precipitation.

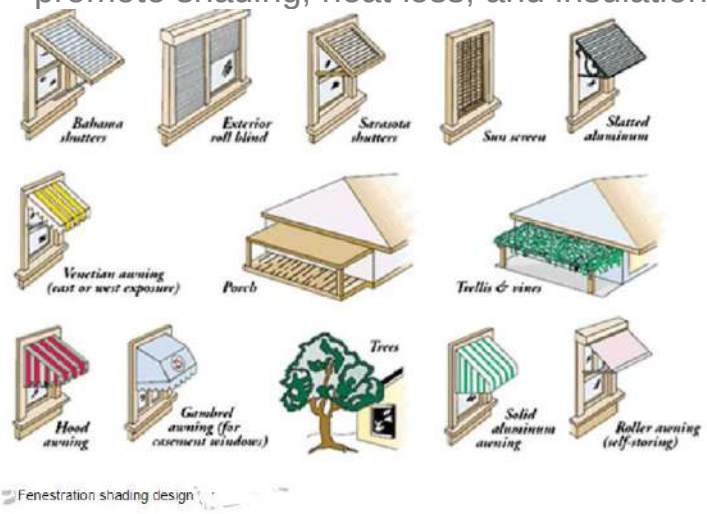
Whereas rainfall is a blessing and can be harnessed for various building services and commercial/industrial purposes, water damage from rain can have devastating effects on buildings and can quickly cause damage after even minimal rain.

Water damage can ruin building contents, and cause costly closures for repairs. Poorly sloped roofs and defective workmanship are readily observed in the event of heavy downpours. Paints and other surface finishes could peel off as result of moisture rise, flooring and floor finishes are not left out too especially for places that are prone to capillary action of underground water.

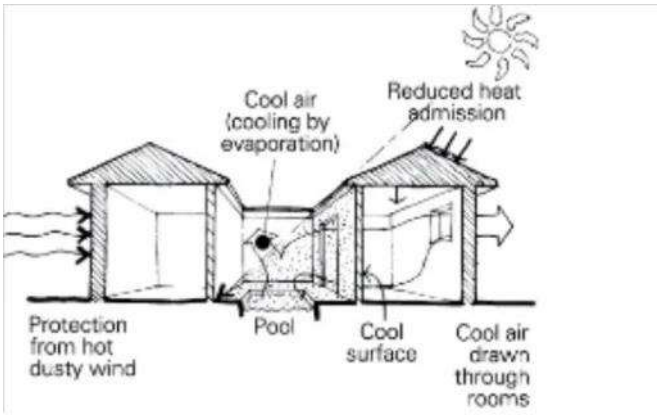
Design Strategies for Hot and Dry Climate

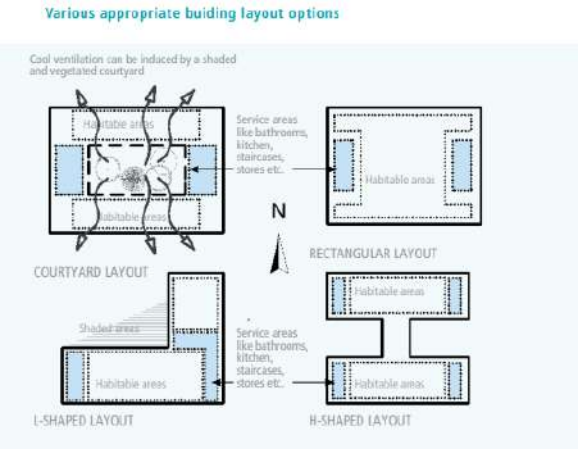
Building Design Strategies:

1. Detailing building fenestration(a term used to describe the arrangement, quality, quantity or aesthetic characteristics of the totality of windows on a building's façade.) design and **construction** details to promote shading, heat loss, and insulation.

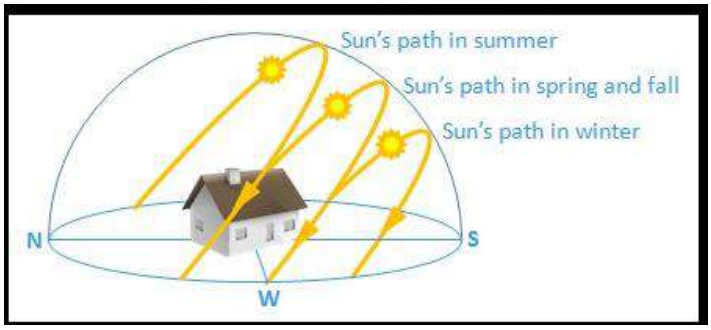


Fenestration shading design

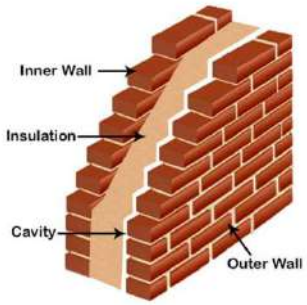




2. Larger building dimensions should face north & south.

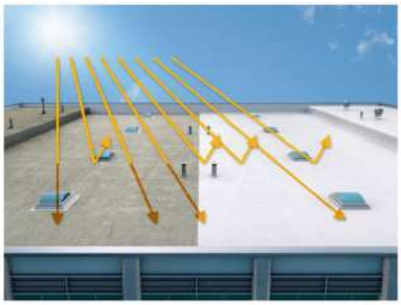


3. Double walls with insulation in between are a suitable solution



4. The size of the windows on the east and west sides should be minimized in order to reduce heat gain.

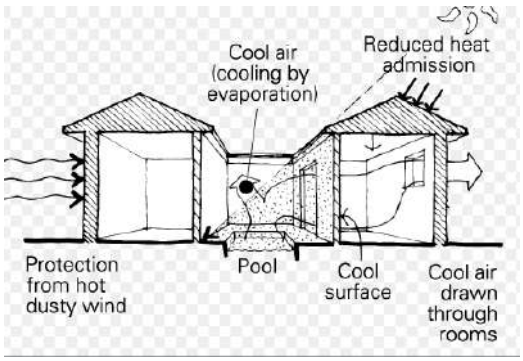
5. The flat roof is a good reflector and re-radiates heat efficiently, especially if it consists of a solid, white-painted material.
   BY choosing the material, we can decrease the temperature too.

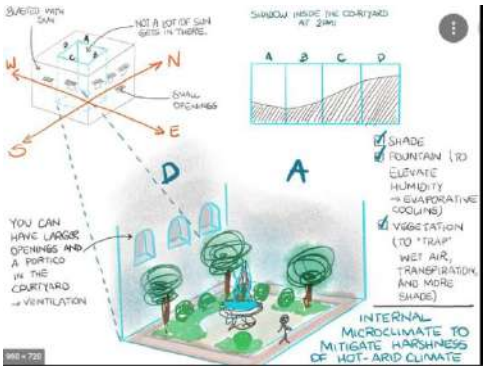


Terra-Cotta Tiles and Ceramic Roofs

6. The courtyard is provided with water and plants, it acts as a cooling source.

Internal courtyards provide cross ventilation and natural cooling.





Inlets are to be provided at lower levels and outlets at a higher level as they serve to vent the hot air.

7. Suitable radiation barriers in the form of canopies, chajjas, and long verandahs should be provided on the west side of the **building**.

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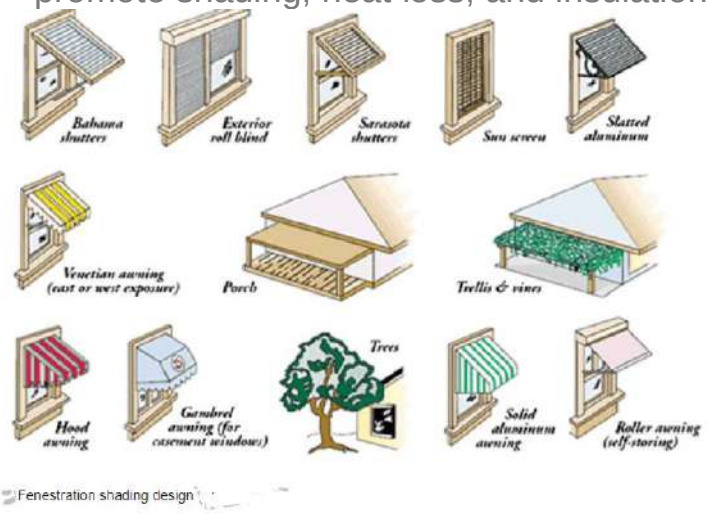

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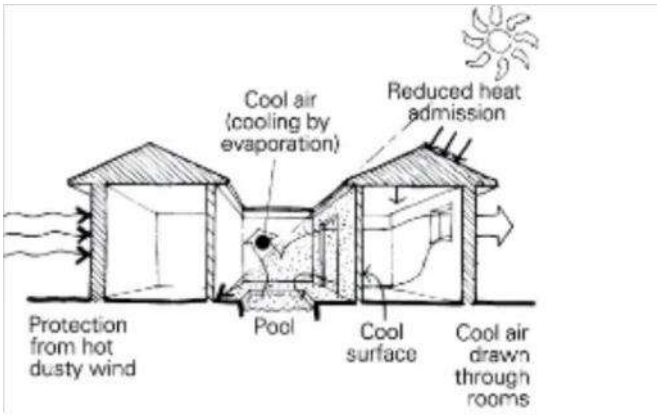

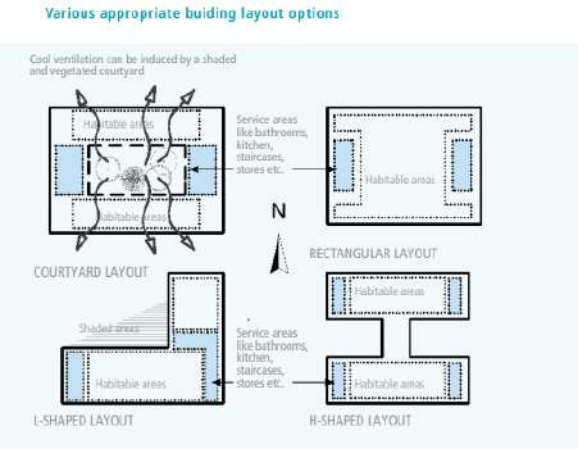

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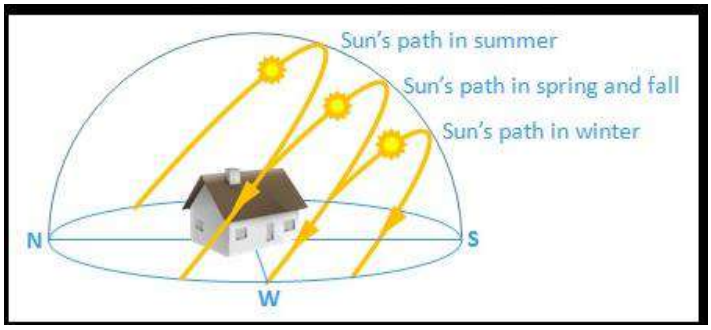

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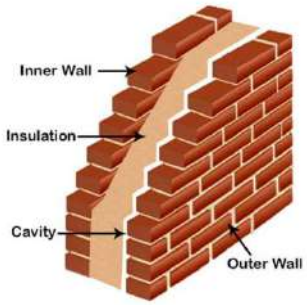

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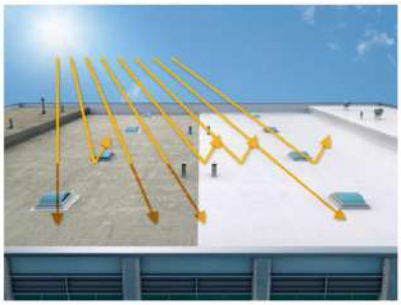

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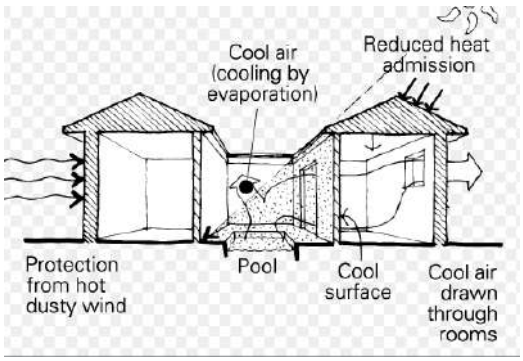

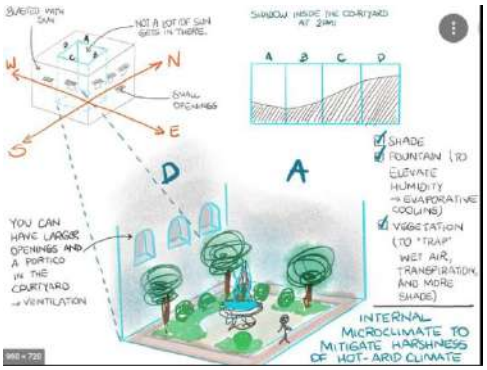

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Orientation of Building

Orientation of building is to **design building in such a way as it receives maximum ventilation and natural light in all climatic conditions.** It provides comfortable living conditions inside the house/building and saves energy bills also. The orientation can defend undesirable effects of worse weather. While planning to build a new house, ask your architect to design building in such a way **that energy loss is minimum.**

Climatic Implication

Orientation of building determines the amount of radiation the building receives. The orientation with respect to air patterns affects the amount of natural ventilation as much as possible.

Benefits of building orientation

Energy saving

Orientation of building is **energy efficient approach** as the building orientation saves heating, cooling and lighting cost. You can take optimal benefits of the sun by maximizing southern exposure. It lowers cooling cost by minimizing western exposure where it is most difficult to provide sunshade.

Breeze/Natural Air

Orientation of building provides breeze is in warm and humid climates. On the other hand, the orientation prevents hot winds in hot and dry climates.

Natural ventilation

Building orientation provides natural ventilation and light which is beneficial to the health of inhabitants of the house.

Factors Affecting Building Orientation

1. Solar radiation and temperature

The intensity of solar radiation depends on the direction of sunrays. The temperature of a structure and living space increases due to sun radiation and affects environment of the house. Solar radiation acts in two ways.

- Sunrays directly come to the house through openings
- Radiation comes indirectly through walls and roof of building by absorbing heat.

For comfortable living particularly during summer season, **radiation, temperature and treatment of room are considered.** From solar radiation point of view, the best orientation

is that which receives maximum solar radiation during winter and receives minimum solar radiation during summer season.

The **South façade has advantage of receiving more solar radiation** during winter than that of receiving during summer. Even for openings on south facade, small overhang such as curtains can cut off direct solar penetration during summer and allows it during winter. Obviously, this is most beneficial aspect, not available on any other façade.

How to minimize solar heat in south façade?

In fact the incidence of ground reflected radiation on human body from southern sun in south facade causes great thermal discomfort and visual glare. In northern India the South wall of a building or house receives least solar radiation during summer. To minimize reflected solar heat, grassy lawns should be developed in front of south façade.

How to minimize solar radiation in western façade?

The eastern and western façade receive nearly equal amounts of daily solar radiation throughout the year. The only difference is when the sun shines on eastern façade, the building or house is comparatively cool and air temperature is low. On the other hand due to higher air temperature in afternoon, the heat flows indoor through western façade. To minimize the affect of solar radiation in western façade, the sunshade on openings should be constructed.

2. Clouds and Rains

Clouds and rains have comparatively less importance in orientation of building. The areas with low clouds cover sky largely and determine the effect of both incoming solar radiation and outgoing terrestrial radiation. Glazing and opening should be designed keeping in view the direction of rain, beating the building because the direction of rain is generally same as that of prevailing wind except in case of storms. If due to architectural view glazing is provided, it should be covered by proper sunshade etc. The walls of lesser thickness should not be designed in the direction of heavy rains.

3. Humidity

It depends on weather condition of the area and has little role in orientation of building. The movement of air and use of prevailing wind are very important during periods of high humidity. Humidity can be classified into four categories i.e.

- **Very dry**
- **Dry**
- **Humid**
- **Very humid**

When humidity is low, dry or very dry, it is easy to take advantage of evaporative cooling in summer. When it is humid or very humid it is desirable to regulate the rate of air movement either artificially with aid of electric fan or with help of prevailing winds.

4. Humidity design consideration

The comfort in relation to humidity becomes complex. In humid environment there is very warm feeling when there is no breeze and air temperature is 30 0C. On the other hand if humidity is low, one may feel cool even if the temperature rises up to 32 0C with little breeze. It will be cooler at the same temperature if there is reduction in relative humidity. And if there is breeze in high humidity area, the building should be designed in such a way as it has more natural air and ventilation.

5. Prevailing winds

Prevailing winds help create natural ventilation in a building and give more comfort during high humidity. During orientation of a building and designing doors and windows openings, the direction of wind flow should be considered. Fix windows and ventilators at proper location in building to provide maximum air and light. The height of windows has much concern about ventilation. Maximum air and ventilation can be obtained if the level of opening is at the level of occupancy.

Consider velocity and direction of wind for orientation

For the purpose of orientation, it is necessary to study velocity and direction of the wind at particular place throughout the year. It is better if the flow of wind is more in building during humid period than rest period of the year.

Close openings to avoid heat and glare in summer

One should take appropriate action during orientation of building so that the building provides maximum comfort. Where there is extreme heat in summer and it becomes necessary to close openings to avoid heat and glare, it would be helpful to orient buildings to face winds during humid months instead of facing prevailing wind which comes from some other direction.

Note: Ideal or desirable orientation may not be possible in each individual case due to various factors in every situation. In this age of advance technology in materials and mechanical aids, the lighting and ventilation can be obtained for living and working after deciding on orientation of building.

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180231

3rd Sem. / ARCH. ASSTT.

Subject : CLIMATOLOGY

Time : 3 Hrs. M.M. : 100

SECTION-A

Note: Multiple choice questions. All questions are compulsory (10x1=10)

Q.1 Earth revolves around the sun from_____

a) north to south b) south to north

c) east to west d) west to east

Q.2 The vertical movement of air is termed as:

a) wind b) air current

c) air turbulence d) air mobility

Q.3 The equator divides the earth into_____ halves.

a) two b) four

c) six d) eight

Q.4 Which instrument is used to measure the relative humidity in the air.

a) hygrometer b) hydrometer

c) hydrograph d) barometer

Q.5 Earth is nearest to the sun on

a) 4th July b) 23rd sept

c) 21st June d) 3rd Jan

Q.6 The main source of natural light is_____

a) flourscent lamp b) mercury lamp

c) sun d) CFL

Q.7 A sun chart is a graph of solar azimuth and solar _____for a particular_____

a) latitude, altitude b) altitude, latitude

c) latitude, azimuth d) latitude, azimuth

Q.8 The natural place where the organism or communities live is known as _____

a) niche b) habitat

c) habit d) biome

Q.9 An element of construction projecting outwards beyond the external vertical face of the wall or facade.

a) sun breaker b) overhang

c) interior louver d) exterior louver

Q.10 The water vapour present in the unit volume of air is called_____

a) relative humidity b) static humidity

c) total humidity d) absolute humidity

SECTION-B

Note: Objective type questions. All questions are compulsory. 10x1=10

Define the following :

Q.11 Insulating Material

Q.12 Humidity

Q.13 Curtain Wall

Q.14 Climatology

Q.15 Precipitation

Q.16 Orientation

Q.17 Pollution

Q.18 Biome

Q.19 Latitude

Q.20 Vertical louvers

SECTION-C

Note: Short answer type questions. Attempt any twelve questions out of fifteen questions.

12x5=60

Q.21 Write the objectives of solar passive design.

Q.22 Explain the movement of earth around the sun.

Q.23 Mention various wind protection devices.

Q.24 Define insulating materials and describe any one.

Q.25 Differentiate between noise pollution and air pollution.

Q.26 Write short note on Global warming.

Q.27 Describe orientation with respect to wind.

Q.28 Write short note on horizontal and vertical sun protection louvers.

Q.29 Describe the controls used for noise pollution.

Q.30 Explain briefly solar passive heating system.

Q.31 Describe various climatic zones.s

Q.32 Explain the basic elements of ecology.

Q.33 List the features of cold climate.

Q.34 Differentiate between micro and macro climate.

Q.35 Explain various Shading devices.

SECTION-D

Note: Long answer type questions. Attempt any two questions out of three questions. 2x10=20

Q.36 Describe how landscape elements can be used for micro climate control.

Q.37 Explain the causes and effects of air pollution.

Q.38 Write a detail note on wind protection devices.